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DOMESTIC ART POTTERY AND ITS MANUFACTURE.*

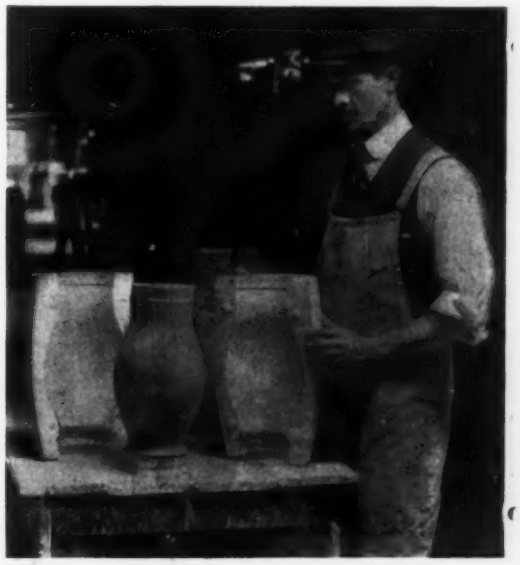
By JANE STANNARD JOHNSON.

THE manufacture of art pottery is one of the industries taken up in America in recent years as a profitable business. Its growth has been rapid, and the products from the potteries are more perfect in artistic beauty each year. Skilled artists and workmen expend brain and brawn striving to attain higher goals in the perfection of these wares, and some beautiful productions are now on the market of American manufacture.

That all things were created for a wise purpose one may believe, though but a small part is comprehended of the wonderful laws of creation in their cause and effect. From very common materials beautiful results are often produced, and nowhere do we find a more impressive example of this than in the magnificent and costly ceramics, china, and art pottery, which are evolved from the common clay dug from the ground, originally clay, but finished a perfectly colored and blended art jardinière or vase. These wares possess an added charm from the very circumstance of their humble origin, and the work of making art pottery presents a subtle charm, for the process is somewhat mysterious, and anything mysterious is usually interesting.

SHOWING HOW SEGGARS ARE PACKED, AND THEIR ARRANGEMENT IN KILN.

SPRAYING ON THE COLORS.



REMOVING A VASE FROM THE MOLD.

POURING "SLIP" INTO THE MOLD.

DIPPING INTO THE GLAZE AFTER FIRST FIRING.

DOMESTIC ART POTTERY AND ITS MANUFACTURE.

First, the clays must be procured from which the bodies of the fine wares are made. These are mined in most instances, but in some cases they are obtained by stripping the earth down to the body of the clay. The clay is composed of several ingredients, such as spar, flint, kaolin, and others, together with some foreign substances which must be removed before the clay can be used.

After reaching the pottery, the several ingredients entering into the composition are weighed, and for this process a most ingenious scale has been perfected. These scales are sealed, so that the person performing the work cannot tell just what weight of each kind of material enters into the mixture. The illustration represents the scales as the clays are being weighed out. The projections on the front of the scales which look like hooks are markers. The body of a vase is composed of various clays and substances, and each one of these hooks represents a certain number of pounds or ounces when the scale is balanced at certain weights. A certain kind of clay is shoveled into the box until the first hook comes down and balances. The hook is then locked, and a certain amount of different clay is shoveled in until the second comes down and balances, showing that the right proportion of this ingredient has been obtained, and so on until the entire mixture is complete. The object in keeping hid from the worker the exact amount of all the different ingredients is to preserve the secret of the body, the composition of which is the first thing a successful potter must know.

After the weighing is completed, the ingredients are thoroughly pulverized and blunged (washed). The mixture then passes through a filter press, after which it is put into a mixing mill and mixed with water to a consistency required for working into ware. The vase

* From American Homes and Gardens. Published by Munn & Co.

may be made by hand or in a mold. If it is to be made in a mold, the clay is mixed to the consistency of thick cream, called "slip," and poured into a plaster of Paris mold. The mold absorbs the water, and as the water oozes into the mold, the clay is carried to the sides, where it clings close. When the mold will no longer absorb water, the remainder of the mixture is poured out of the mold. The shell of clay thus gives the form of the vase. From the mold, the vase goes to the finisher, who trims, sponges and smooths up the piece, and removes all defects.

If it is to be an underglazed art vase, it next goes to the blender, who sprays it with a clay liquid containing mineral colors, green, blue, or others. Next, the vase goes to the artist, from whose hands it receives decoration in flowers, animals, or figures. This painting is done in colored clay, and much skill is required as well as experience in its application, for the color of the clay changes in the firing, and must be thoroughly understood by the artist. After having been decorated, the piece goes to the drying-room and remains there until the water has evaporated. It is then placed in the kiln and given the first firing. When it comes out it has been reduced to the biscuit state.

SHAPING TOP OF JARDINIÈRE.

WEIGHING OUT THE DIFFERENT CLAYS FOR MIXING.

The kiln is a wonderful place in itself. Within its rough brick walls are placed immature and fragile things which shall eventually become valuable pieces of art, if there be no accident in the firing. The kiln is cleverly arranged to fire the ware in a series of small clay boxes, called "seggars." These are filled with the clay vases, standing side by side, and the boxes are then piled in the kiln, one above the other in tall columns called "bungs." Men place these in position by climbing up ladders. When the kiln is all ready, the fire is started. The heat is gaged by a pyrometer so accurately that the heat may be gaged within ten degrees. The fine glazes require very high temperature, while less heat is needed for what is called the "mat" finish.

When the ware comes from the kiln after the first firing, it is dipped into a solution called glaze, which is really liquid glass. The piece of ware is then fired again. When taken from the kiln a second time, it is a beautiful piece of pottery.

This is only one process of making a vase. Different wares require different processes. If a color glaze is wanted, the result is obtained by another method. The vase in clay form is placed in the dryroom, after which it is burned once, producing the biscuit state. Then the color glazes are applied, which are made by mixing various colored minerals in the glaze. After having been burnt again it comes out of the kiln a perfect piece of ware.

In case an overglaze effect is desired, the piece of ware in biscuit state is dipped into a transparent glaze, after which it is fired and comes out of the kiln plain white. It is then taken to the decorating room, where it receives an application of what is known as overglaze colors. These are minerals which melt or fuse at a low heat. After these colors and the gold desired are applied, it is again burned in what is known as a gold kiln at a low heat. This makes the gold bright, and also brings out the other colors to the desired shades.

These are the principal processes by which different kinds of pottery are made. Experiments are constantly being carried on to produce effects never before obtained, and in pottery as in painting, the artists endeavor to secure the rich colors and effects given us by artists of previous centuries.

Many beautiful wares have been placed upon the market by domestic manufacturers. Some of these are made without any attempt at reproduction from any ware, while some very clever reproductions have been made of wares centuries old. A notable one of the latter is the Henri Deux ware. The original of this was made in France between the years 1524 and 1537, and so called because of the frequent occurrence of this monarch's cypher in the decoration. Only fifty-three pieces of the original ware are said to be in existence, valued at $140,000. The forms in most cases are very elaborate. The ware is a fine white clay to which a delicate tinge has been given by a slight tinge of yellow in the glaze. The patterns, which are very intricate, and seem to have been suggested by the ornate book covers of that period, have been pressed into the clay, whereupon these sunken portions were filled up with different colored clays in yellow, buff and brown. As all these clays had to be shrunk during the firing in exactly the same proportion, the difficulties attending the manufacture may well be imagined. It was an ambitious undertaking indeed to attempt to reproduce a ware of this character.

Another ware, perhaps the most comprehensive of all domestic wares, is called the Gloss Utopian. This is highly glazed in rich browns with the yellow tints and blends so often seen in pottery. It comprises large and small pieces, from the umbrella jar to a tiny vase. One odd piece is a teapot after the old Egyptian shapes, and another is a Calabash whisky jug. The decorations used on this ware vary, according to the use for which the piece is ordained. Some pieces have animal or floral decorations, while the decoration of more pretentious vases and plaques is often a head of some celebrity or an Indian. No two pieces are ever decorated with the same head.

Perhaps one of the most costly of American wares is the opalescent inlaid ware. In making this, the gold is laid over the clay. Then the vase is splattered with a pure white mineral, through which the gold shows. The decorations of flowers and conventional designs are inlaid in gold.

One does not, in these days of beautiful pottery, need to be urged to take an interest in this beautiful art. Our modern potters are making more and more beautiful work daily, work beautiful in form, fine in texture, and original in decoration. Moreover, we have all the beautiful pottery of earlier periods to see and enjoy, and the enjoyment is not the less because much of the best of it has found permanent homes in the museums. On the contrary, this is a distinct advantage, since many more people are able to delight in it. The making of modern pottery is, however, becoming more and more an art and less a manufacture. The advantages of this change are many and obvious.

VARIETIES OF SHAPES AND DECORATIONS OF FINISHED POTTERY.

DOMESTIC ART POTTERY AND ITS MANUFACTURE.

Etching Fluid for Copper, Brass, and Bronze.—The surface covered with the proper ground on which the design has been traced is covered with the following fluid: Fuming muriatic acid, 10 parts, diluted with 70 parts of water, is mixed with a boiling solution of 2 parts of chlorate of potash to 20 parts of water; the whole is diluted with 100 to 200 parts of water.

THE SILICON DETECTOR, AND MEASUREMENT OF ELECTRIC WAVE ENERGY.

By WILLIAM MAVER, JR.

THE desideratum from the beginning of radio-telegraphy has been to obtain a simple, reliable, efficient, and economical auto-detector. The Branly filings detector, which has the distinction of having been the first successful wireless receiver, is simple enough, but it is not automatic as to decohering; it requires battery in its operation, and is not as a rule continuously reliable. Its proneness to variations of resistance detracts from its efficiency where sharp tuning is desired. Its sensitiveness also is very low, comparatively speaking. The magnetic and the electrolytic detectors are very sensitive and fairly reliable receivers, but the one requires moving apparatus and the other requires external battery in its operation.

The silicon detector, due to Mr. G. W. Pickard, appears to have realized to a marked degree the enumerated essential features that are desirable in a radio-telegraph detector.

The Pickard detector is of the thermo-electric type of wireless receivers. The electrodes employed are pure silicon *S*, and a metallic element of low resistance, *m*, Fig. 1. The energy of the electric oscillations established in the vertical wire at the receiving station by incoming electric waves is converted into joulean heat (C^2R) at the element having high resistance and high thermo-electromotive force, which heat is converted at the contact point into a short pulse of direct current in the telephone receiver *T*.

In the experiments which led Mr. Pickard to adopt silicon for this purpose he tested over two hundred materials as thermo-electric junctions. Nearly all of these couples gave some results, provided the area of contact and pressure at the contact were suitable; but no satisfactory stable material, with high thermo-electric force against the other element, other than silicon, was found.

According to Mr. Pickard, the efficiency of a silicon-metal junction is due to the very thin layer of silica with which an exposed surface of silicon is always coated. In this respect it resembles aluminium. This layer of silica is so thin that good electrical contact may be obtained through it, yet it interposes a relatively high and exceedingly compact resistance in the immediate vicinity of the junction. This resistance acts as a heater, quite efficiently converting the oscillations into a direct electric current in the circuit.

The best arrangement of this detector consists in the employment of a small piece of silicon of hemispherical shape the round surface of which is held in a metal cup; the other electrode is a piece of pointed metal impinging on the flat surface of the silicon. But a fragment of silicon merely held with suitable pressure between the flat-ended brass rods gives excellent commercial results.

Mr. Pickard has made numerous tests by means of specially devised apparatus to determine the sensitiveness of various detectors, as well as to measure the wave energy of received signals. The method consists in comparing the intensity of the discharge of a small condenser against that of the received signals according to the arrangement shown in Fig. 2. The ordinary receiving circuit, consisting of inductance *L*, capacity *C'*, silicon detector *K*, and telephone receiver *T*, is shown at the right of a switch *S*. A substitution circuit including a small condenser *C*, potentiometer *P*, and battery *B*, is shown to the left of the switch.

By throwing the switch to the right the operator hears the dots of arriving signals in the telephone *T*. Throwing the switch to the left and dotting on key *K*, single discharges of condenser *C* are observed in the telephone. By throwing the switch to the right and left alternately, and by varying the potential in the substitution circuit by means of the potentiometer, the discharge of condenser *C* is made to equal that from the antenna *A*, as indicated by the intensity of the sounds in the telephone. Then, knowing the capacity of *C* and the potential to which it is charged, the energy of the received signals may be calculated by the formula:

$$W \text{ (ergs)} = CV^2$$

where *C* is capacity and *V* is potential in volts.

In the tests conducted by Mr. Pickard a silicon receiver was employed. It was found that at a distance of 90 miles from the transmitting station the energy of the received signals varied from 0.02 to 0.06 erg. A high-resistance telephone receiver such as is employed in radio-telegraphy will give a clearly-defined dot from the single discharge of a condenser the energy of which is equal to 0.23×10^{-6} erg. The electrolytic detector at a period of 500,000 cycles per second requires 364×10^{-6} erg to produce a signal of corresponding intensity in the telephone. These figures Mr. Pickard points out clearly indicate that were it not for the inefficiency of the telephone at high frequencies, it would far excel the most sensitive detectors of electric waves now in service.

The foregoing method has also been employed by the same investigator to measure the sensitiveness of various types of detectors, with the following results:

Electrolytic	0.000364 to 0.000400 erg.
Magnetic	0.000400 to 0.000430 erg.
Silicon	0.000430 to 0.000450 erg.
Carborundum	0.000900 to 0.014000 erg.

These measurements show that the silicon detector is practically of the same order of sensitiveness as the electrolytic detector. In practice the actual difference in the sensitiveness of the carborundum detector is not so perceptible in the telephone receiver as would be indicated by these tests, the explanation being that the human ear does not determine sound in direct proportion to its intensity, but rather as the ratio of the square roots of the intensity of the sounds.

SAND-LIME BRICK.*

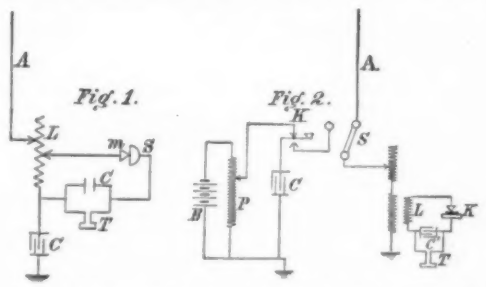
By E. W. SMYTHE.

THERE seems to be a general impression that sand-lime brick is a new and untried building material; scarcely out of the experimental stage. Although sand-lime brick can not boast of a pedigree traced to the time of the Pharaohs or the Tower of Babel, still it has been in use long enough to establish without doubt its quality as a first-class building material.

Sand-lime brick were first made in Potsdam, Germany, about 1820. Potsdam, situated in central Germany, is surrounded by a broad sandy plain; there being no clay or stone available for building purposes, sand and lime were made into mortar, molded into bricks and allowed to cure from three to four months in the open air. These brick withstood all the required tests, and increased in hardness with age. The attention of Dr. Michaelis, of Berlin, in 1880 was attracted to this peculiar kind of brick, and after experimentation he discovered, that by subjecting the green brick to steam under pressure the brick after a few hours were rendered as hard as though they had been exposed to the atmosphere for many months. After the discovery made by Mr. Michaelis, the manufacture of sand-lime brick increased rapidly throughout Germany and many large plants for their production were erected.

In our own country the oldest sand-lime brick of which we have any record are those in the walls of a house in Mobile, Ala., built fifty years ago. As to whether these brick were made in this country or elsewhere is not known, but at any rate they are in good condition and appear to have been made in a manner similar to those first made in Germany.

But not until 1901 were sand-lime brick manufactured in any considerable quantity in the United States; during this year two plants were in operation. In 1903 there were 16 plants; in 1904, 57, and in 1905, 130. At present there are probably about 200 plants. Among these plants there is a great diversity in the manner of handling and combining their materials. These differences occur from local conditions and the way in which they hydrate the lime and the manner of incorporating the lime with the sand.



In a general way, I shall now describe the process of manufacturing sand-lime brick as carried on by the plant in this city, and then refer briefly to some of the methods used by other manufacturers.

The sand as it is brought in dump cars from the bank is shoveled into an elevator boot from which it is elevated about 35 feet, and discharged upon a vibrating screen. Here it is run through a ¼-inch mesh screen and falls into a conveyor over the numerous coils of a steam drier. The sand must be perfectly dry. There can be no half-way place in regard to the dryness of the sand, for you cannot mix sand and lime intimately unless both are thoroughly dry. The wet sand as it rests upon the pipes dries and runs down into a hopper-shaped bin in the bottom of which is a conveyor for drawing the sand out as it is needed.

The lime is slacked in water-tight steel boxes mounted on wheels. Each of these has a capacity of about 450 pounds of dry slacked lime, a quantity sufficient for one thousand brick. The quicklime is weighed out, placed in the boxes and the proper quantity of water added to it. To determine the correct amount of water to apply to the lime in order that a dry slack may be secured, is not always easy, as the lime when received at the factory is nearly always more or less air-slacked, and also there is considerable variation in the quality of lime even when the limestone comes from the same ledge. After applying the water the lime cars are run under the brick cars in the same cylinder in which the bricks are hardened, and the slacking is thus completed, and the surplus of moisture (if not too great) dried out. The dry slacked lime is now dumped from the cars upon a "grizzly" which takes out all the large cores. Passing through the "grizzly," the lime descends into a hopper and is conveyed to an elevator which discharges it into a bolting machine where all the small cores are extracted. Leaving the bolting machine the lime falls into a bin directly opposite the bin containing the dry sand.

Between the lime and sand bins is a measuring device, and the dry sand and lime are brought to it by conveyors placed in the bottoms of their respective bins. The right proportions being measured out, the mixture is allowed to fall into a preliminary mixer where for two or three minutes the sand and lime receive their first mixing. Passing on from this mixer the sand and lime are fed by a conveyor into a tubemill where they are thoroughly ground and mixed, and each grain of sand is completely coated with minute lime particles. Leaving the tubemill the mix is at once elevated to a pugmill where just sufficient water is added to cause it to cling together when compressed tightly in the hand. The pugmill discharges the dampened material into a 4-mold press. The green brick are loaded upon cars, 1,000 to a car, and run into a large steel cylinder 50 feet long by 6 feet in diameter. After filling the cylinder (which holds a day's run) live steam is turned into it. About two hours are required to bring the steam pressure up to 120 pounds per square inch, which pressure is maintained for eight hours. After steaming, the brick are ready for market. Twenty-four hours have elapsed since the sand left the bank until it leaves the cylinder a finished brick ready to lay in the wall. In several instances we have afforded masons the unusual pleasure of laying hot brick on a cold morning.

In the process of manufacture just described the lime was slacked before incorporation with the sand, but in some processes the quicklime is ground, then mixed with the sand and passed through a tube or ballmill. After grinding, the proper amount of water is added, and the mixture is conveyed to a silo where it is permitted to slack and cure for 24 or 48 hours. It is then withdrawn and made into brick. Others grind but a part of their sand and lime, and some do no grinding whatever. There are some factories which use the damp sand directly as it comes from the bank; to this damp sand damp slacked lime is added. The two are run through a short pugmill, then to the press and made into brick. The process is beautiful for its simplicity, but the product is not a credit to the sand-lime industry.

The materials entering into the manufacture of sand-lime brick are as common as those entering into the production of clay brick, but as all clays are not suitable for making good clay brick so all sands are not suitable for making good sand-lime brick. The sand must be clean and contain a high per cent of silica. Of all the impurities in sand, clay, iron oxide and feldspar are the most common. The latter two may be left out of consideration, as they seldom appear save in small quantities. Clay, however, is nearly always found in sand and many times in considerable quantities. To determine what effect the presence of clay has upon the strength of sand-lime brick, S. V. Peppel, a member of the Ohio Geological Survey, made some valuable experiments. He made up numerous samples of brick, varying in each the percentage of clay. Upon testing these brick he found that up to three per cent addition of clay very little change took place in the strength of the brick, but for amounts over this there was a decided decrease both in crushing and tensile strength. It was also interesting to note that small amounts of clay decreased slightly the water absorption of the brick, acting to some extent as a waterproofing agent.

For the manufacture of sand-lime brick a high calcium lime is by all means the best. Magnesian limes while they give just as strong a brick as do the high-calcium limes yet they are too slow in slacking and one runs considerable risk in using them, since if the lime is not thoroughly slacked before the brick go into the hardening cylinder slacking will continue, and the lime expanding will crack and ruin the brick. The best practice demands eight per cent by weight of slacked lime. A less amount of lime than this does not give a brick first class in strength; and a larger per cent of lime than this, while it adds slightly to the crushing strength of the brick, it also adds to the water absorption, and incidentally to the cost.

To secure the best results the lime must be thoroughly mixed and ground up with the sand. For this mixing and grinding there are various machines upon the market which can be used. Among them are the tubemill, ballmill, and gyratory mill. The last two mills mentioned have one advantage over the former, that is of being able to handle the material when it is slightly damp, whereas in the tubemill a trace of moisture in the material causes the lime to stick and form a coat over the sides of the silex lining, in which case little or no grinding is done by the mill. However, the material being dry, of these three classes of mills I believe the tubemill to be the best, as it not only gives a very finely ground product but also gives a more thorough mix than the other two mills. Another point in its favor is that the cost of repairs on a tubemill is considerably less than that required by the ball or gyratory mill.

In the manufacture of sand-lime brick the machinery is subject to much greater wear and strain than that used in the production of clay brick, and the maximum of this wear centers in the grinding mill and the press. The press must be massive and built to withstand excessive strains, because a slight variation in the amount of water added to the mix makes a very great difference in its compressibility; therefore the press must have a large surplus of strength in order to withstand this extra stress which will most likely be brought upon it. Within the press the greatest wear is on the mold box and mold liners. A set of the best liners will turn out about 100,000 perfect brick. Beyond this number they become considerably worn and the edges of the brick are feathered and rough so that they are suitable only for common brick.

In steaming the brick two methods can be fol-

* Read before the Wisconsin Clay Workers' Association.

lowed to secure the same result: either a high steam-pressure for a few hours or a low steam-pressure for a comparatively longer period. In either case the brick will attain the same degree of hardness. Most manufacturers are, however, agreed that 8 hours at a pressure of 120 pounds per square inch (2 hours being required to bring the cylinder up to this pressure) is the best and most economical practice. The steam must not be turned in too fast, as the surfaces of the brick will become highly heated while the interiors remain cold; the unequal expansion thus produced causes the brick to check.

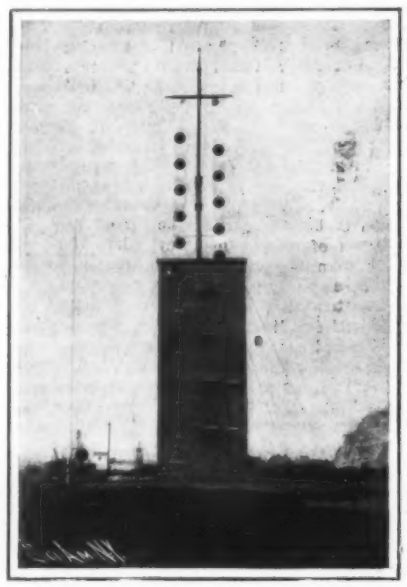
Through the overzealous efforts of machinery jobbers, who think only of disposing of their machinery, an erroneous impression has been spread abroad that sand-lime brick can be manufactured at an extremely low cost. The cost of manufacturing sand-lime brick depends upon the same variable quantities as does the manufacture of clay brick or any other product. Labor and fuel are the main items in the manufacture of brick and to produce brick cheaply a dollar's worth of labor must be got for every dollar paid for labor, and for every pound of fuel the greatest possible number of heat units must be utilized. It is the stopping of the little leaks that make the profits in manufacturing.

THE BOYD AUTOMATIC TIDE SIGNALING APPARATUS.*

AN ingenious signaling apparatus has been installed at the entrance to the harbor of the port of Irvine in Scotland, the only one of its type in operation. For some years past the authorities of this harbor have been severely handicapped by the difficulty of informing the captains of incoming vessels of the state of the tide, since at low water entrance cannot be effected, and vessels must wait outside the bar for the next tide. The only means available of warning the incoming vessels was a tugboat, and naturally such precautionary measures proved expensive. These shortcomings were so detrimental to the progressive development of the harbor's prosperity, since vessels preferred to put in at some of the adjacent ports to discharge their cargo, that the authorities requested the harbor master, Mr. Martin Boyd, to devise some certain means whereby captains of incoming vessels could learn the depth of water within the navigable channel, and whether the tide was flowing or ebbing, at any time of the night and day from several miles out, and arrange their plans accordingly.

The present apparatus is the outcome of Mr. Boyd's efforts, and is the result of two years' experimentation. This apparatus possesses several ingenious features, and moreover is entirely automatic. In the design of this apparatus the inventor has caused the rising and falling tide to indicate the depth of water within the navigable channel.

At a prominent point near the harbor entrance, a tower has been erected, as shown in the accompanying illustration. Within this tower at the base has been installed gearing connected with a float which is moored in the navigable channel leading to the harbor, and which has a perfectly free rising and falling motion with the tide. Carried on the top of the tower is a staff, upon each side of which are signal balls, twelve in number, working on cables and staggered. Each ball represents a foot rise or fall in the tide. The device by which these balls are raised and lowered from sight is connected with the gearing below. The float in the river is set at a zero point which corresponds with 7 feet of water, at which depth only one ball is visible above the top of the tower. Immediately the depth has increased by one foot two balls become visible, one on each side of the staff, three balls with the second foot rise, and so on until the twelve balls can be seen, at which time there is a depth of 18 feet of water in the fairway. The turn of the tide causes a reversal of the operations, one ball disappearing from sight with every one foot of fall in the water until a depth of 7 feet is again attained, when the cycle of operations is repeated, rising and falling alternately and continued without cessation. The depth of water indicated is that which prevails in the center of the channel with smooth water. Owing to the positive working and indication of the apparatus, mariners cannot calculate upon a greater depth of water than is actually shown by the reading of the signal balls, more especially on the ebb, neither can any allowance be made for any sea, and furthermore there is generally less water at either side. In addition a block signal is shown consisting of two black balls in a vertical line exhibited from a flagstaff immediately adjacent to the signaling tower. The readings, however, cannot be confused, as the balls on the signal station are staggered, while the block signals are vertically one above the other. Mariners are thus warned when it is impossible for some means or other, such as a wreck in the fairway, to enter the harbor, and similarly the same signal serves to warn mariners on outgoing ships within the harbor of the impossibility of leaving their anchorage.

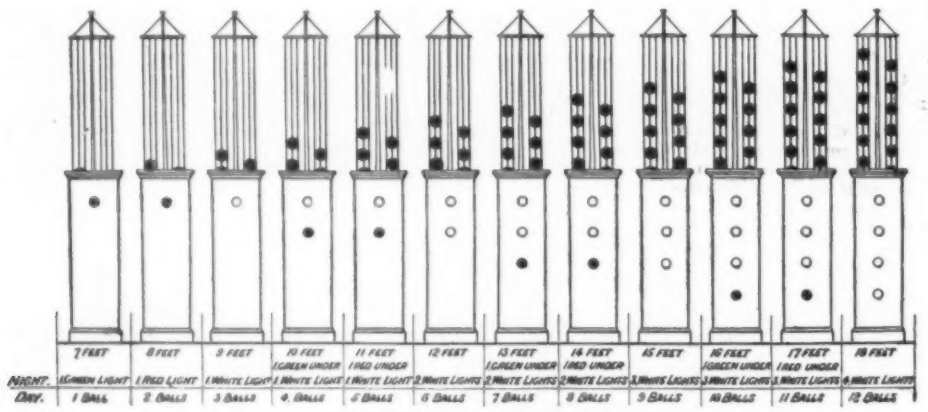


THE BOYD AUTOMATIC TIDE SIGNALING APPARATUS AT IRVINE HARBOR, SCOTLAND.

To inform incoming ships of the depth of water in the channel. In this picture ten balls are visible, indicating a depth of 16 feet in the navigable channel.

Owing to the prominent position occupied by the signal station, the code can be read for many miles distant at sea, and by comparison with the signal code issued by the harbor authorities the captain is able to ascertain at a glance the depth of water in the channel, and by watching whether the balls increase or decrease in number, accurately learn whether the tide is ebbing or flowing.

For night signaling an ingenious arrangement has been provided, acting in concert with the signal balls. As may be seen in the illustration, the front wall of the building is pierced in a central vertical line at regular intervals by four orifices. These openings are fitted with powerful lenses. Through these openings signal lights are thrown, corresponding with the reading by the balls, varying in color either green, white, or red, according to the printed code. Thus for instance when there is 7 feet of water in the channel, one green light is visible. When the tide rises a foot an eclipser comes into action, and converts the green light into a red. The next foot rise similarly eclipses the red for a white light. By combination of these three colors any state of the tide between the zero at 7 feet and the maximum of 18 feet is shown, the reading for the latter comprising four white lights in a vertical line. As the tide falls the arrangement is reversed until the zero is once more regained. For the block signal at night two red lights one above the other are displayed. An ingenious feature of the night arrangement is that the apparatus automatically shuts off and turns on the lights as required according to the signal code, thereby effecting an economy in the consumption of the gas, which is the illuminant employed.



THE CODE OF SIGNALS, NIGHT AND DAY.

Shown by the Boyd Automatic Tide Signaling Apparatus, indicating the depth of the navigable channel.

It will be seen that the movement of the float in the channel governs the whole of the movements of the signaling apparatus, thereby rendering it entirely automatic in its action, so that it can be left without the slightest attention for days without any apprehensions as to its safe operation. Moreover, it is infallible; and owing to the small number of moving parts involved in the gearing, the possibility of breakdown is extremely remote. The night signals, as in the case of the signal balls, can be readily observed several miles distant, owing to the utilization of the lenses.

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

WHAT ARE EARTHQUAKES?*

By HUDSON MAXIM.

THERE are few subjects less understood than earthquakes. Among the many theories that have been advanced to explain them, there are none, to my mind, not open to serious objections. The theory here presented I believe to be in the main new.

The three recent terrific seismic disturbances at San Francisco, Valparaiso, and Kingston, following the eruptions of Mont Pelée and Vesuvius, forcibly remind us that there is a tremendous terranean power of some sort underlying the deep foundations whereon we build our cities and our hopes.

The most common explanation offered is that the earth's shrinkage from loss of heat sets up stress in the earth's crust, which becomes greater and greater until the crust yields along old faults or lines of weakness.

Few people have any idea how enormous are deep earth pressures, or know that these pressures must be taken into serious account in the study of seismic phenomena.

It matters not whether the earth be considered as a solid all the way through, or as consisting of a great molten interior with a relatively thin crust upon it, for solid rock and molten lava behave the same at depths of a few miles. *Granite flows like wax at a depth of fifty miles, and the earth is eight thousand miles in diameter.* If the molten interior of the earth were to be removed and the space filled with air under a pressure sufficient to sustain the crust, this air, were it not to liquefy, would immediately under the crust have a density greater than gold.

If two tempered solid steel balls the size of the earth, hard as the harveyized face of armorplate, were to be taken in two Jovian hands and placed gently together in space and released, what would happen? They would behave exactly as though they were liquid, and would fall together and coalesce with each other like two drops of water, while the highest prominence or mountain on the new globe thus formed could not have a height of fifty miles, because it would flatten out under its own weight.

If we had a tank, say five hundred miles in height, made of material refractory enough and strong enough, provided with a faucet at the bottom, and should fill it to the brim with cannon balls, hard files, and steel rails, we could, without the application of any heat, draw the molten steel from this enormous tank, because, under its own weight, the steel would be forced to flow in a stream through the faucet.

There are two causes which work together to produce earthquakes: first, the escape of pent-up steam and molten matter, followed by the settling of the crust to fill the voids; second, the tension in the earth's crust set up by contraction from loss of heat. The shrinkage of the earth from loss of heat is so slow, however, that this factor is not so important; besides, the weight of the earth's crust is so great that the bedrock flows and adjusts itself to the stresses produced by mere shrinkage without producing earthquakes or volcanoes. This shrinkage, however, holds the ledges under tension, and the tension aids in the earth movements produced by the disturbing element of water. Water heated to incandescence in a space where it can not expand exerts a pressure equal to that which would be produced by the most powerful dynamite exploded in the same space. The effect is the same as though many portions of the earth's crust were actually resting upon gases of exploded dynamite trying to escape.

The theory is frequently advanced that planets, and even suns, sometimes explode, and that the earth may some day blow up like a bombshell. No celestial body the size of the earth could possibly explode. If the entire molten interior of our globe could be replaced with nitroglycerin and detonated, the explosion would not lift the earth's crust. In other words, if we assume that the crust of the earth is from fifty to one hundred miles in thickness, it would require something much more powerful than even nitroglycerin to burst this shell. It is necessary only to do a little figuring to see that the pressure of the earth's crust at a depth of from fifty to a hundred miles far exceeds the pressure exerted by the most powerful high explosive.

If we assume that the thickness of the earth's crust is fifty miles, and that its average density is about five times that of water, then we may also assume that the pressure at a depth of fifty miles is somewhat in excess of half a million pounds to the square inch. It is a safe conclusion that within a large portion of the earth's crust there exist pent-up gases, particularly steam, under a pressure equal to that exerted by the most powerful high explosives. High explosives probably exert pressures ranging from 200,000 to 350,000 pounds to the square inch. When a high explosive is detonated, the amount of pressure depends upon the volume of gases liberated and the temperature of the gases. Nitroglycerin exploded in a space where it could not expand would exert a pressure of probably from 300,000 to 350,000 pounds to the square inch. The pressure would certainly be less than half a million pounds to the square inch, although the temperature of the gases would equal the boiling point of steel. As

*Success.

the density of water is not quite so great as that of nitroglycerin, the pressure which incandescent water exerts is not so great as would be exerted by pure nitroglycerin, volume for volume. But weight for weight, the energy exerted would be virtually equal. In deep subterranean chambers there are necessarily large quantities of water heated to a temperature representing a pressure equal to that of exploded dynamite.

Through all geologic time, water, always water, has been both builder and destroyer. Water has piled the mountains up and ground them down again with storm and glacier, pulverizing the *débris*, sifting and separating sand from pebble, and stone from bowlder; cutting deep cañons in the rock, laying out the plain, throwing islands into the sea, and giving continents new coast lines.

Water, too, was the original architect of the earth's crust. There was a time when the globe was too hot to allow water to remain on the surface in a liquid state. Then the ocean hung in the sky in the shape of steam, mixed with a vast amount of carbonic acid gas, for then the great beds of peat and coal had not yet been formed. From this great vaporous envelope the heat was quickly radiated into the cold of outer space, producing rapid condensation. Through long ages Niagaras of rain plunged from sky to earth in a continual downpour over the entire terrestrial surface. The pressure of the superincumbent atmosphere was then many thousands of pounds to the square inch, instead of but fifteen pounds to the square inch as now. Under such enormous pressures the boiling point of water was not, as we know it, 212 deg. F., but was red heat. The first rivers that flowed upon the earth's surface were red-hot. Granite dissolved in those floods like sugar in a cup of tea. The granite bedrock was formed by the precipitation of mica, quartz, and feldspar from aqueous solution. Deep down under the earth's crust to-day, where water has entered through faults, to be entrapped and highly heated, with no room for expansion, it dissolves the rock. And as, under the enormous pressures, it forces its way through narrow crevices to new positions, it cuts new channels in the granite floors, just as in glacial time subglacial streams cut passages through the ice. Consequently, when the eruption of a volcano takes place, relieving the pressures in the deep passages under it, there is a rush toward the outlet, of streams of incandescent water made syrupy with stone in solution. As these streams of silica-charged water find vent at the volcano, the expansion of the pent-up stream takes place with explosive violence, forming volcanic dust and pumice stone, which are belched forth in stupendous quantities. Then portions of the earth's crust, which have been resting upon a support of steam under dynamite pressures, naturally sag and shift when those pressures are removed or materially lessened.

It matters not whether under the deep subterranean pressures and temperatures the incandescent water be actually liquid or gaseous; its density is the same. Under such conditions, there can be no finely-drawn line between the liquid and the gas.

The pressure exerted by water under these conditions is sufficient to cause subterranean streams of lava and quartz-charged water to flow to long distances, even thousands of miles, leaving vast voids behind. The bedrock then settles and closes the passages, just as in glaciers the ice yields and closes the courses of subglacial streams.

A granite glacier fifty miles high would flow exactly like a glacier of ice a mile thick. The bedrock is a vast rock glacier threaded by numerous waterways which erode and cut passages through it, and the water courses are again closed by the yielding walls of granite under the awful pressure just as the glacial waterways were closed by the yielding ice. The earth's surface then assumes new levels, this adjustment resulting in earthquakes.

The vast amount of solid matter ejected at times from volcanoes is difficult of comprehension. The great volcano Krakatoa had been extinct for ages when, in 1883, its top blew off with a shock felt clear through the earth, and with a blast that sent a wave of air around the earth three times, while the fine volcanic dust did not entirely settle out of the atmosphere for more than two years, as was indicated by the unusually brilliant display of red sunsets. It is estimated that more mud was ejected from the mountain on that occasion than the Mississippi River discharges in two hundred and fifty years. This was the greatest volcanic eruption in historic times. The distance is not too great nor the time too remote for the eruption of Mont Pelée to have caused the earthquakes of San Francisco, Valparaiso, and Kingston, while possibly Vesuvius may have played a material part.

CEMENT PIERS.

AFTER a ten years' test of the cement cylinder piers at San Francisco by the State Harbor Commission, it is accepted that that form of dock construction has come to stay, and that in all probability no stone docks will ever be built on the Pacific ports.

The first of these cement cylinders were put in on the San Francisco water front in 1894, and have undergone the test of time at the dock, which is used by the army transport service. The cylindrical cement piers under this dock, which has been in constant use by the transport service, show no signs of deterioration.

No port on the Pacific had previously felt able to provide for the cost of construction of stone docks, such as have been built at immense outlay in the harbors of the Old World. Freight sheds of simplest design supported on wooden piling adorn the water fronts of the harbors of Washington, Oregon, and California.

The life of the wooden piers is only four years. Attacked by the *Limnoria terebrans* between the high and low-water marks, and eaten by the *Teredo navalis* from the low-water mark down to the mud, the wooden-pile dock was but a makeshift at best, and the harbor commissioners of the American ports have been confronted by a serious question.

Three large docks are now under construction in San Francisco, supported by cement piers. Two of these are for the Pacific Mail Company and the third for coast traffic, and the commission has permanently committed itself to the cement dock. The result is that, instead of issuing $200,000,000 of bonds as at Liverpool, or $40,000,000 as at Calcutta and Antwerp, to run for long periods, the San Francisco docks will be paid for in a short term of years out of their own rentals, while the rentals of stone docks only provide for the payment of interest on debenture bonds.

In the construction of the two docks for the Pacific Mail Company little change has been made in the type as it was first designed by Howard C. Holmes, chief engineer of the San Francisco Dry Dock Company, in December, 1900.

These two piers, which are 650 feet long and 140 feet wide, rest on cement cylinders, which are constructed in the following manner:

A cluster of three wooden piles 50 feet in length is driven close together and to slightly different depths. Around these is placed a wooden stave cylinder, of four feet inside diameter, which is driven with the ordinary piledriver used for driving the three piles in the center. The cylinders are of Douglas fir staves four inches thick and bound together by steel bands with tightening lugs. After these have been driven from 10 to 15 feet into the mud, the water and mud are pumped out to a depth of four feet below the outside mud level. A cylinder of expanded metal is then placed around the piles inside the wooden cylinder, which is then filled with a rich concrete of broken rock and hydraulic cement, contained in 25-pound bags for the first five feet.

Structural-steel caps are set on the top of the cylinders, and the wharf floor laid of steel I-beams and fir stringers and planking.

The strength of these cylinders is independent of the wooden stave coverings, which may rot away in time, leaving the interior cement with its protected cluster of piles intact. In practical experience it has been found that the ravages of the ship worm on these staves is not nearly as great as in the case of the ordinary piles, which soon become honeycombed.

In building these last three docks, a temporary floor was put down and tracks laid upon it, on which the concrete was conveyed in ore cars to fill the cylinders. The cars were filled from a double-decked mixing contrivance, having two tilting boxes in which the concrete was alternately mixed and dumped into the cars.

Besides the eight completed docks in San Francisco and the three under construction, the government has adopted the cement cylinder in the quarantine wharf now being built at Honolulu, and other government work is contemplated.

Naturally, the entire freedom from frost in San Francisco has been in favor of cement construction, and it may be that that is one reason that the California harbor commissioners have been the first to permanently adopt the cement dock, but the inventor claims that with ordinary protections against ice the cement cylinders will stand in any latitude.

The illustration shows the work of the ship worm (*Teredo navalis*) on the piling of the section of the old dock left standing during the placing of the new cylinders.

CONSTRUCTION OF A CEMENT PIER.

Experiments have been carried on by J. Tribot at Paris upon the evolution of carbon, water, and ash in function of age, in plants. In this case he took barley as the subject of experiment. It was sown in flower pots and placed under a shed, so that the plants received only diffused light. At the beginning of the tests, which were made in the suburbs of the city, all the pots were filled with the same earth, as homogeneous and nearly alike as possible. The age of the plants which were examined varied regularly from 18 to 96 days, using 23 different pots in the tests. First he measured the average height of the stalk and found it to be 4.2 inches at 18 days, or at the start of the test. There seems to be a maximum for the height about the 74th day, and then it commences to diminish, the highest value being 26 inches. As regards the amount of water in the plant, he finds that starting from the maximum point there is a slow dehydration which is well marked; thus at 18 days we find 89.67 parts water for 100 of the plant, at 71 days 91.22, which is the highest, and at 96 days, or the end of the test, 79.59 per cent. The amount of mineral matter as shown by analysis of the ash, also diminishes after a certain point, and this is in concordance with the results of the author's preceding analyses upon the mineral matter contained in bones. The variation of the percentage of ash in the plants depends not only upon the age, but also upon the composition of the earth, which is necessarily somewhat variable, and to eliminate the influence of the earth, he calculates the ratio between the percentage of ash of the plant and the ash of the earth. This ratio rises very rapidly during the first period of growth of the plant, then more slowly, passing by a maximum between the 40th and 50th days, then lessens gradually toward the end. At the beginning or 18th day it is 0.170, at the 49th day it is 0.226 and at the 96th day it drops to 0.166. Comparing the percentages of the carbon of the plant and the carbon of the earth, it is seen that there is no relation between these two quantities, and the carbon of the earth remains about constant in the experiments while that of the plant varies, having a maximum which nearly coincides with that of the ash. The present researches may be taken as the preliminary work upon a series of researches as to the evolution of the quantity which Solvay designates as Ef/Ec, where Ef represents the energy taken up by the plant and given off in the heat of combustion, while Ec is reduced, according to the conclusions found above, to the calorific and luminous energy.

THE TEMPERATURE OF THE EARTH'S INTERIOR.

By Prof. JOHANN KOENIGSBERGER.

AT a small depth (from 12 to 40 feet) below the surface of the earth the temperature is constant throughout the year, and this constant temperature of the soil differs little from the mean annual temperature of the air, except on mountains more than 6,000 feet high. The ground is cooler in summer and warmer in winter than the air above it. For this reason caves were the first habitations of men and cellars are still used for the protection of food supplies from rapid changes of temperature.

The fact that the temperature of the earth increases with increasing depth below the surface was first clearly enunciated in 1662, by Kircher, who had obtained his data from Hungarian mining engineers. The first measurements of this increase of temperature were made by Friesleben, Humboldt, Saussure, and others at the commencement of the nineteenth century. We are now in possession of many good measurements made in various countries, but the results are so discordant that it is difficult to deduce a general law of the increase of temperature. Some of these results are shown in the following table, which gives the geothermic interval, or the increase in depth which corresponds to a rise of temperature of one degree, and also the geothermic gradient, or the fraction of a degree by which the temperature rises per unit of depth. The geothermic gradient is the reciprocal of the geothermic interval.

A	B	C	D	E	F
Places.	Mean Interval.		Mean Gradient.		Remarks.
	Meters per Deg. C.	Feet per Deg. F.	Deg. C. per Meter.	Deg. F. per Foot.	
1. Paruschowitz (Silesia)	34.0	62	0.0294	0.016	Plains in northern and central Germany; non-oxidizable, chiefly sedimentary rocks.
2. Berlin	32.0	58	0.0313	0.017	
3. Artern (Thuringia)	37.7	69	0.0266	0.015	
Mean of seven places in North Germany	34.6	63	0.0290	0.016	
4. Schemnitz (Hungary)	39.8	73	0.0253	0.014	Plains.
5. La Mouillonge	30.6	56	0.0326	0.018	
6. India	36.7	67	0.0273	0.015	
Mean for plains exclusive of Germany	33.4	61	0.0300	0.0165	
7. Mont Cenis Tunnel (middle)	50.0	91	0.020	0.011	Measured during the boring of tunnels under mountains.
8. St. Gotthard Tunnel:					
(a) At the mouth in the valley	29.4	54	0.034	0.019	
(b) At the middle in the mountain	45.5	83	0.022	0.012	
9. Simplon Tunnel:					
(a) At the mouth in the valley	28.0	51	0.0357	0.020	
(b) At the middle in the mountain	48.7	89	0.0206	0.011	
10. Pribram	59.0	107	0.0170	0.009	
Mines of Lake Superior:					
11. Osceola	42.0	76	0.0238	0.013	Near great lakes or oceans.
12. Mines nearer the lake	55.0 to 67.0	100 to 122	0.0182 to 0.0150	0.010 to 0.008	
13. Calumet and Hecla on peninsula in lake	122.8	224	0.0081	0.004	
14. Plains of Utrecht	52.0	95	0.0193	0.011	
15. Macholles (France)	14.6	27	0.0685	0.038	Near recent volcanic tertiary magmas.
16. Dakota (United States)	9.6 to 12.8	17 to 23	0.104 to 0.078	0.057 to 0.043	
17. Glasgow (coal fields)	25.5 to 7.8	47 to 14	0.039 to 0.128	0.021 to 0.070	In coal and oil fields.
18. Anzin (France)	26.7 to 15.3	50 to 28	0.0375 to 0.0651	0.021 to 0.036	
19. Pechelbronn	13.9	25	0.0730	0.040	

From this table it appears that the differences between the values are very great. Are these differences attributable to errors in measurement, or to unsuspected peculiarities of the various rocks, or is the apparent irregularity subject to definite laws? They cannot be entirely due to errors in measurement, for such causes of error as the heat produced by the drill, or currents of air and water in the borings could scarcely change the temperature by more than 3 or 4 deg. F., which at a depth of 2,000 feet would produce an error of only 7 per cent in the gradient and interval. (In mines, however, the lighting and ventilation and the engines and machines may cause errors of 30 per cent or more.)

Many geologists attribute the great variation in the temperature gradient to complex irregularities in the structure of the earth's crust. Some even maintain that the interior of the earth is cold and that the observed elevation of temperature is due to local and very irregular generation of heat. Most geologists, however, assume that the earth's interior is hot and ascribe the great variation in the observed temperatures and gradients to differences in the thermal conductivity of the rocks and to the influence of subterranean water courses, the arrangement of strata, and other causes that cannot be directly determined.

Dr. Thoma and the writer have endeavored to prove or disprove this theory and introduce order into the apparent chaos of observed results. We have deduced the abnormal temperature gradients mathematically from the known laws of the conduction of heat, taking account of the modifications which the configuration of the earth's surface and the proximity of veins of ore, seams of coal, and volcanic magmas introduce into the simple conditions presented by the sedimentary and unchangeable rocks that underlie the great, low-lying plain of North Germany.

Most of the gradients are abnormal because most of the observations were made in tunnels under mountains or in mines of coal or metal, that is, in the vicinity of substances which produce heat in consequence of the oxidizing action of the air, either in gaseous form or dissolved in water. The measurements may be classed according as they were taken:

1. In unchangeable sedimentary rocks under plains remote from mountains and large bodies of water (measurements 1-6).
2. In tunnels under mountains (7-9).
3. Near large bodies of water (11-14).
4. In regions of recent volcanic activity (15-16).
5. In coal mines, oil fields, and deposits of oxidizable minerals (17-19).

The first object of our investigation was purely scientific—the explanation of observed facts with the aid of as few assumptions as possible. The second object was practical—the exact prognostication of the temperatures to be encountered in tunneling, the prediction of volcanic eruptions, and the determination of the existence of hot lavas near the earth's surface.

For the purpose of our calculations it is indifferent whether the observed temperatures are due to the cooling of a molten interior (as Kant, Laplace, Fourier, and Poisson assumed), to mechanical action (Mallet), to chemical and radioactive processes (Himstedt), or to all of these combined. Our only assumptions are that the mean of the results obtained in a region remote from mountains and large bodies of water represents the normal value and that Fourier's differential equation of the conduction of heat is true and applicable.

We have calculated the gradients and temperatures under mountains and valleys with the following results:

Tunnel.	Distance from Mouth, Meters.	Observed Temperature, Deg. C.	Calcu'ated Temperature, Deg. C.
St. Gotthard	700 to 900	13.8 to 15	14.9 to 15
St. Gotthard	3500	25.9	25.9
St. Gotthard	6500	31.7	32.1
St. Gotthard	9500	25.2	25.9
Mont Cenis	Middle	29.5	30.4
Simplon	Middle	32.0	49.0

The agreement is so close that it is evidently possible to calculate in advance the temperatures to be encountered in tunneling with quite sufficient accuracy for practical purposes.

Great effect has been ascribed to the dip and the order of strata, but our experiments on the thermal conductivity of various wet rocks (all the Alpine strata are saturated with water) in various directions prove that this effect is very small. The cooling or heating effect of streams of water depends on the extent of surface that they wash. The springs of St. Gotthard are too small and compact to have an appreciable effect except in their immediate vicinity.

Near large masses of water the geothermic interval is greatly increased and the gradient correspondingly diminished by the conductivity of the water. A lake covering 400 square miles to a depth of 600 feet can diminish by one-half the gradient at a depth of 1,600 feet and a distance of six miles from the lake. The best examples of this influence of water are offered by the mines of Lake Superior. The geothermic interval is 76 at the Osceola mine five miles from the lake, 100 to 122 at mines nearer the lake, and 224 at the Calumet and Hecla mines on the Keweenaw peninsula.

From the measurements of the interval in recent volcanic regions not containing ores or coal the depth at which molten lava occurs may be computed. From the formulæ for an ellipsoidal mass of a diameter exceeding six miles and the temperature gradient deduced from observations near the surface at Neuffen, in the vicinity of a tertiary crater and basaltic overflows, we find a temperature of about 1,500 deg. F. at a depth of four or five miles. Our calculations also indicate that variations in the activity of a volcano must be reflected in the temperature gradient of the vicinity, and that three observations of the temperatures at depths of 16 feet and 50 feet should suffice to determine to a fair degree of accuracy the location and form of the subterranean mass of liquid lava. Unfortunately, we have no records of this character. I have devised an apparatus costing from $75 to $150, for the purpose of registering the changes in the mass of lava by means of the variation of the geothermic interval, and thus, perhaps, predicting volcanic eruptions.

Over veins of coal and some other minerals the temperature gradient is high, while below them it soon attains the normal value. The same results are given by the mathematical theory applied to deposits of spherical or ellipsoidal form. We find that a spherical mass of 100 meters radius, with its center 400 meters below the surface, would increase the temperature gradient immediately above it from 0.030 to 0.050, if the generation of heat in the mass is 3,400 gramme-calories per second. This is equivalent to a yearly combustion of 100 grammes of carbon and hydrocarbons on each square meter (approximately 3 ounces per square yard) of the surface of the mass. This calculation shows that no very great production of heat is required to cause a considerable change in the observed temperature. Hence, it is theoretically possible to cool mines by refrigerating chambers suitably distributed beneath and beside the galleries, if the chambers are sufficiently large and numerous and well insulated, so that all the heat which they absorb is taken from the rock.

The temperatures and gradients in the interior of the coal or ore can also be computed, but each case will differ from the rest.

From the foregoing considerations it is evident that the abnormal temperature gradients can be explained very simply and without the introduction of new hypotheses, by the varying production of heat in coal seams, the proximity of volcanic masses, and the cooling effect of large bodies of water. The mathematical method, instead, offers to the mining engineer and tunnel constructor a very valuable means of calculating the temperatures of shafts and tunnels in advance with a fair degree of accuracy, when something is known of the geological conditions.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

SOME PROPERTIES OF VANADIUM STEEL.*

HOW SMALL QUANTITIES OF VANADIUM AFFECT DIFFERENT MIXTURES OF IRON AND STEEL AND WHERE IT IS MOST USEFUL.

By E. F. LAKE.

VANADIUM steel is the latest product of alloyed steels that has been brought out by the steel makers in the past few years, and while there are many things to be decided, by practical tests, as to its good or bad qualities, enough is known to warrant its being placed among the high grades of steel.

Like many of the materials used to alloy steel to raise its tensile strength, elastic limit, elongation, and resistance to shock stresses, vanadium was discovered by the chemists about one hundred years ago, and was christened erythonium, this being confused with the better known element chromium. About thirty years afterward it was re-discovered and renamed vanadium, but its chemical properties were little understood until within the last few years, when an Englishman isolated metallic vanadium for the first time, after a thorough investigation of this element and its salts.

One of its compounds, ammonium vanadate, brought $160 a pound as late as 1871.

Pure vanadium has a specific gravity of 5.5, and its melting point is 3,640 deg. F., but it is never obtained pure except in the laboratory, as the expense of puri-

* The American Machinist.

fying prohibits its use commercially. When obtained pure it is a silvery white metal.

The high degree at which it fuses would prohibit its use in steel, but for the recent discovery of the fact, that an alloy of iron, containing from 30 to 40 per cent of vanadium, has a much lower fusing point than ordinary steel, thus enabling the steel makers to produce an open-hearth steel with vanadium as an alloy.

This discovery was brought about by the fact that vanadium was found to be present in the Swedish and Faeberg irons, which were the softest irons produced at that time, as well as having a ductility that was remarkable. The percentage of vanadium in these irons runs from 0.17 to 0.26 in four pigs, which were examined, but even with this large percentage of vanadium, its ready oxidizability to vanadic acid caused the greater part of the metal to slag off. Thus the slag from blast furnaces working on this metal is rich in vanadium, one test showing a pig with 0.015 per cent of vanadium, while the slags showed 2.5 per cent. One blast furnace in France treated this slag and obtained from 80 to 100 tons of the oxide per year, which was used for ink making, and in textile works, for the fine black which it produced.

The principal sources of the metal, however, are: (1) Vanadinate, which is a mineral containing about 40 per cent of lead, 12 to 13 per cent of vanadic oxide, and silica, iron, and silver as the other ingredients. This is obtained in Spain. (2) The vanadiferous sandstones of Colorado. (3) The vanadiferous deposits in South America.

These last two are guarded with a certain amount of secrecy, as they are controlled by one company, which is working under government patents. We see in this, as in many other things, a product that has taken many individuals over a hundred years to develop, and when it has been developed to a point where it is commercially useful, the developers are dead and some individual steps in, obtains patents, and reaps all the pecuniary benefits from a product that was given to the world by its discoverers and developers.

In obtaining the metal from the ore, the oxide is concentrated and this is reduced in the presence of oxide of iron by the extreme heat of an electric furnace, or by the use of aluminium, both processes being similar and producing a ferro-vanadium of different percentages, as high as 80 per cent of vanadium having been frequently obtained.

Vanadium is similar to aluminium, both chemically and in its action on steel in producing soundness or making it homogeneous, and it affects steel when applied in extremely small doses. It must be applied properly, however, as it possesses the property of "elusiveness" to a very high degree.

Examination under a microscope shows that it has the power of retarding the segregation of the carbides, which makes the steel easily tempered; this can be done by simply heating to about 1,600 deg. F., and quenching in water without re-heating. Under this condition vanadium steel gives considerable elongation, a great resistance to shock stresses, a very high tensile strength, and the elastic limit is brought up nearer the tensile strength than any other alloy of steel which I know of.

This is best shown by one test bar ⅝ of an inch round, which we analyzed and tested. This test bar showed on analysis that it contained:

	Per cent.
Vanadium	0.268
Nickel	2.54
Carbon	0.156
Manganese	0.42
Phosphorus	0.022
Sulphur	0.028

Its physical characteristics in the annealed state were:

Tensile strength, per square inch	85,290 pounds.
Elastic limit, per square inch	69,540 pounds.
Elongation in 2 inches	34.0 per cent.
Reduction of area	57.5 per cent.

After heating to 3,650 deg. F., which would be a cherry color, and quenching in water, without reheating, its physical characteristics were:

Tensile strength, per square inch	218,300 pounds.
Elastic limit, per square inch	194,820 pounds.
Elongation in 2 inches	10.1 per cent.
Reduction of area	18.3 per cent.
Torsional test	1,673 degrees.
Or 4.77 complete turns before fracture	
shock stress, Seaton and Jude test.	71

Vanadium also toughens the micro-constituent, ferrite, which shows a close interlocking granular formation, and it is possible to cold-bend square bars of the steel double, which can be done cold without its showing the least sign of fracture.

One of the characteristics of vanadium steel is its low carbon content, which is generally from 0.10 to 0.15 per cent, and as they are manufactured to-day, both in Europe and America, might be placed in three classes, these being: (1) steel containing vanadium only; (2) steel containing vanadium and nickel; (3) steel containing vanadium and chromium.

The first is usually composed of from 0.10 to 0.15 carbon and from 0.15 to 0.25 per cent vanadium. Vanadium is nearly as powerful as carbon in its effects on steel and should be classed as one of the wonders of applied science, owing to the fact that a few tenths of one per cent raises the tensile strength of very pure iron (that, for instance, which is electrolytically deposited) from 5,400 to 60,000 or more pounds per square inch, and nowhere in metallurgy or any other branch of applied science do we deal with quantities that are so vast in effect and yet so small in quantity.

Vanadium is being added to carbon steel on account of its producing a ductility of a large degree when added to steel in very small amounts, with the result that it also raises the tensile strength, the elastic limit and its toughness, as shown by bending double.

An experiment was made by taking a mild steel, low in phosphorus, and adding vanadium of different percentages to it. The following table shows the results obtained:

	Tensile Strength in Pounds per Square Inch.	Elastic Limit in Pounds per Square Inch.	Elongation in Two Inches. Per Cent.
Mild steel, low in phosphorus	60,000	34,400	17.0
The same, carbonized by melting in graphite crucible	62,000	46,000	23.0
With 0.5 per cent vanadium added, unannealed	94,000	74,000	11.0
With 1.0 per cent vanadium added, unannealed	138,000	112,000	7.3
With 1.0 per cent vanadium added, annealed	102,000	82,000	18.0

With 1 per cent of vanadium added the last steel was very soft but attained great hardness by heating to 3,650 deg. F. and quenching in water.

This grade of vanadium steel welds as easily as wrought iron, which puts it in a class by itself. It is generally used for such mechanism as has to withstand vibration. At the same time it is fairly high in tensile strength and elastic limit.

The second class, steel containing vanadium and nickel, is manufactured in several grades and usually contains from 0.2 to 0.4 per cent of vanadium, with nickel varying from 2 to 6 per cent. These combinations give a tensile strength, per square inch, of from 78,000 to 87,000 pounds, an elastic limit of from 62,000 to 71,000 pounds per square inch, and an elongation in 2 inches varying between 30 and 35 per cent. After tempering, without re-heating, the tensile strength rises to 200,000 or 220,000 pounds; the elastic limit from 185,000 to 195,000 pounds, and the elongation in 2 inches reduces to from 10 to 8 per cent.

Nickel has a peculiar action on steel in that, up to 8 per cent it renders steel hard, from 8 to 15 per cent it makes it so brittle that it can be powdered under a hand hammer and its mechanical properties are not readily ascertained by experiment; from 15 to 25 per cent a rapid rise in extensibility occurs, which increases more slowly after this. Added to a high carbon steel, nickel makes it difficult to harden locally, although it may be oil tempered, and also makes it liable to show "pipes" and "seams." Vanadium, however, makes steel more ductile and homogeneous and therefore when added to nickel steel, a few tenths of one per cent overcoming the tendency to show "pipes" and "seams," makes it easily tempered, and largely reduces the zone of brittleness which nickel gives to steel, although it is seldom, if ever, used in steel with the nickel component over 8 per cent.

Nickel gives steel an ability to withstand shock stresses although the design may be intricate and full of holes, and vanadium adds to this quality as well as raising the tensile strength and bringing the elastic limit up close to it.

This makes a steel that is specially fitted for piston rods, connecting rods, coupling rods, light axles, etc., and while it is not quite up to the standard set by chrome-nickel steel, it is so much easier to machine and temper that many are using it owing to the reduced cost of the finished product.

The difference in tensile strength, elastic limit and shock stress is so slight between these two steels, that it does not warrant the added expense in working which is attached to the use of chrome-nickel steel. But for the highest grades of machinery it will be some time before this is replaced.

The third class—that is, steel containing vanadium and chromium—is being produced in several different grades, of which the two best known are of the following composition:

	Per cent.
Carbon	0.20
Chromium	1.00
Vanadium	0.20
and	
Carbon	0.40
Chromium	1.00
Vanadium	0.20

The general influence of chromium on steel is to increase the tensile strength and resistance to shock. It also has a tendency to produce a mineral hardness which makes it difficult to work hot, and it is only welded successfully by the aid of electricity, owing to the tendency of the chromium to oxidation and the formation of slag.

Two per cent of chromium added to steel makes it very difficult to cut or machine when cold. The Carnegie Steel Company, after much experimenting, found that about the only way it could successfully cut the chrome-steel armor plates was with a very high speed friction disk. They made a high-speed steel disk about 6 feet in diameter, mounted it the same as a circular saw, and by driving this at a high rate of speed it would wear its way through the armor plates. Plates 6 inches thick were cut on the same principle as a board is cut on a circular saw, except that the saw had no teeth and a stream of water was kept running at the cutting point.

Steels containing chromium only are seldom used for other purposes than armor plate on war vessels, as it seems to withstand the impact of shots better than any other kind of steel.

Vanadium added to chrome steel in quantities of from 0.15 to 0.25 per cent neutralizes this tendency of chromium to produce a mineral hardness and renders the steel comparatively easy to cut and machine. It also raises the tensile strength and at the same time the elastic limit is raised more than the tensile strength is. It also gives steel a remarkable resistance to torsional strains and by the addition of vanadium to chrome steel a steel is produced that is particularly adapted to the manufacture of crank shafts, propeller shafts, railway axles, gears, ball-bearing cups and cones, etc.

The fact that vanadium gives steel a high degree of ductility and at the same time increases its tensile strength and elastic limit, makes it one of the best of steels for crank shafts for multiple cylinder internal-combustion engines, owing to the intense strains which they have to stand from the explosion. As this steel can be bent double without showing signs of cracks a crank shaft can be bent to shape, out of a solid bar, thus making the grain of the steel follow the shape of the crank. After bending, it should be annealed in order to remove any internal strains.

This would make a stronger crank shaft than one forged in a slab and then slotted out, as well as effect a great saving in material.

As for instance a six-throw crank shaft worked out of the slab weighs when finished 72 pounds—in one example that I know of—while the slab before it is operated on weighs 360 pounds. This is where the crank shaft is made out of a very high grade of steel, but one that will not stand bending as will vanadium steel. The best results with this steel are obtained by working it out of the slab, but at the same time what little grain there is to the metal is cross grain in several places in the shaft.

The vanadium steel, bent bar, would weigh about 175 pounds for a finished crank weighing 72 pounds, thus saving about one-half in the material used.

In the automobile business in Europe this steel is fast coming into use for motor-car engines, as a compact, light, and powerful car is the ideal aimed at and demanded.

The results of chromium and vanadium added to steel are best shown by the following table:

	Tensile Strength in Pounds per Square Inch.	Elastic Limit in Pounds per Square Inch.	Reduction of Area, Per Cent.	Elongation in Two Inches, Per Cent.
Carbon manganese steel (plain)	56,000	34,000	60	35
The same plus:				
0.5 per cent chromium	72,000	46,000	61	33
1.0 per cent chromium	80,000	52,000	57	30
0.10 per cent vanadium	72,000	60,000	60	31
0.15 per cent vanadium	76,000	64,000	59	26
0.25 per cent vanadium	82,000	72,000	59	24
1.0 per cent chromium and 0.15 vanadium	102,000	76,000	57	24
1.0 per cent chromium and 0.25 vanadium	128,000	104,000	46	19
1.0 per cent chromium and 0.15 vanadium, hardened	178,000	148,000	48	16
1.0 per cent chromium and 0.25 vanadium, hardened	202,000	188,000	45	12

These tests were made from crucible steel and to them should be added a torsional and shock test as the tendency in the past few years has been to raise the tensile strength with the result that static ductility has been sacrificed and when used on machinery which had to stand high shock stresses or torsional strains as in the modern automobile, sudden fracture was the result. The breaking of crank shafts in boats and axles on railroads has also been due to a brittleness in steel that was high in tensile strength and elastic limit, and showed a good elongation, but at the same time the brittleness did not show itself until submitted to the shock and torsional tests of actual use.

Vanadium has also been used in malleable iron with good results, and many different combinations of vanadium and other alloys are used in steel for different purposes. One combination—other than those described—is said to make excellent material for springs and another is claimed to be a very high-grade tool steel. The properties it impresses upon steel may be said to lie between carbon and chromium.

In conclusion I might say that vanadium steel being of such recent origin much is yet to be learned of its good or bad qualities, as for instance we do not know the extent to which it may be forged, hardened or machined, and also what its wearing qualities are. The tests given vanadium steel have mostly been experimental and laboratory tests, and these show quite conclusively that it is excelled only by nickel-chrome steel and for some purposes may be as good as that, although it would be a difficult proposition for it to show better wearing qualities for gears than nickel-chrome steel. But the future may bring developments that will improve on the present quality. From the present outlook, based on what is known of it, it is liable to replace and exclude nickel, tungsten and molybdenum steels.

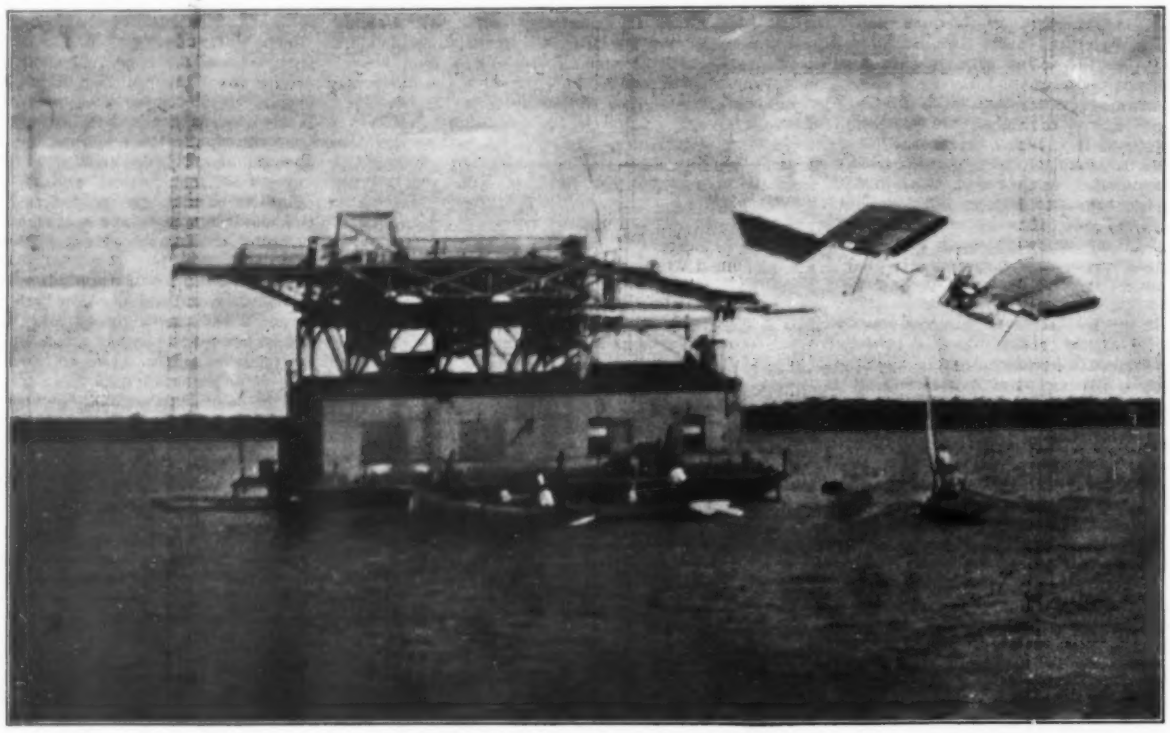
AERIAL LOCOMOTION.

WITH A FEW NOTES OF PROGRESS IN THE CONSTRUCTION OF AN AERODROME.*

By ALEXANDER GRAHAM BELL.

THE history of aerial locomotion is full of tragedies, and this is specially true where flying machines are concerned. Men have gone up in balloons, and most of them have come down safely. Men have launched themselves into the air on wings, and most have met with disaster to life or limb. There have been centuries of effort to produce a machine that should fly like a bird, and carry a man whithersoever he willed through the air; and previously to 1783, the year sacred to the memory of the brothers Montgolfier, all experiments at aerial locomotion had this end exclusively in view.

Then came a period when the conquest of the air was sought through the agency of balloons. For more than one hundred years the efforts of experimenters were chiefly directed to the problem of rendering the balloon dirigible; and the earlier experiments with gliding machines, and artificial wings, and the projects of men to drive heavy bodies through the air by means of propellers were largely forgotten. The balloon was changed from its original spherical form to a shape better adapted for propulsion; and at last, through the efforts of Santos Dumont, we have arrived at the dirigible balloon of to-day. But in spite of the dirigibility of the modern balloon, it has so far been found impracticable to impart to this frail structure a velocity sufficient to enable it to make headway against anything but the mildest sort of wind. The character of the balloon problem has therefore changed. Velocity of propulsion rather than dirigibility is now the chief object of research.



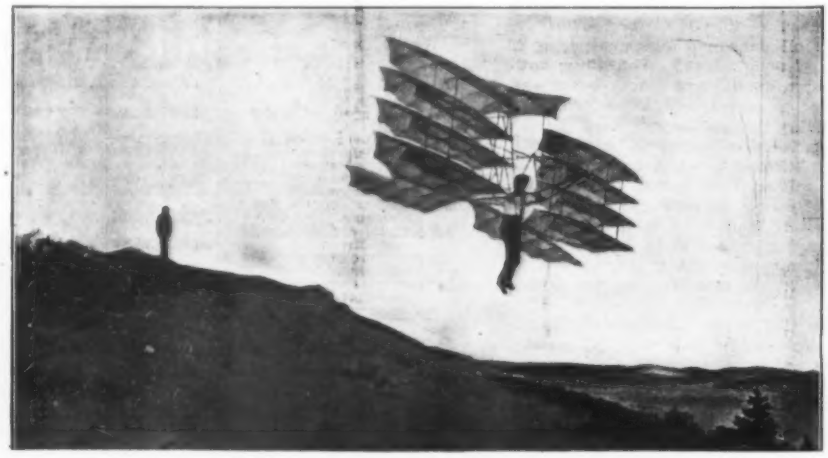
THE ACCIDENT TO LANGLEY'S AERODROME.

From an instantaneous photograph lent by the Smithsonian Institution and published in the National Geographic Magazine. The machine was caught in the launching ways and was injured, being precipitated into the water without having a chance to show what it could do in the air.

* An address read before the Washington Academy of Sciences, December 13, 1906, and specially revised by Dr. Bell for publication in the National Geographic Magazine.

THE BIRDS ARE ONCE MORE RECOGNIZED AS THE TRUE MODELS OF FLIGHT.

It has long been recognized by a growing school of thinkers that an aerial vehicle, in order to cope with the wind, should be specifically heavier than the air



GLIDING THROUGH THE AIR ON CHANUTE'S MULTIPLE-WINGED GLIDER.

From the National Geographic Magazine.

LILIENTHAL GLIDING MACHINE AS REPRODUCED IN AMERICA FOR CHANUTE BY HERRING.

From the National Geographic Magazine.

LANGLEY'S AERODROME NO. 5 IN FLIGHT, MAY 6, 1896.

From instantaneous photograph by Alexander Graham Bell.

through which it moves. This position is supported by the fact that all of Nature's flying models, from the smallest insect to the largest bird, are specifically heavier than the air in which they fly, most of them many hundreds of times heavier, and that none of them adopt the balloon principle in flight. It is also significant in this connection that some of Santos Dumont's most celebrated exploits were accomplished with quite a small balloon, so ballasted as to sink in the air instead of rise. He was then enabled, under the influence of his motive power, to steer his balloon upward without the expenditure of ballast and to descend without the loss of gas. This probably typifies, for the balloon, the direction of change in the future. A reduction in the volume of gas coincidently with an increase in motive power will lead to greater velocity of propulsion, now the main desideratum. Then dependence upon velocity for support rather than gas may gradually lead to the elimination of the gas bag altogether; in which case the balloon will give birth to a flying machine of the heavier-than-air type.

However this may be, it is certainly the case that the tendency of aerial research is to-day reverting more and more to the old lines of investigation that were pursued for hundreds of years before the invention of the balloon diverted attention from the subject. The old devices have been re-invented; the old experiments have been tried once more. Again, the birds are recognized as the true models of flight, and again men have put on wings, but this time with more promise of success.

THE GLIDING FLIGHTS OF LILIENTHAL.

Lilienthal boldly launched himself into the air in an apparatus of his own construction, having wings like a bird and a tail for a rudder. Without any motor, he ran down hill against the wind. Then, upon jumping into the air, he found himself supported by his apparatus, and glided down hill at an elevation of a few feet from the ground, landing safely at a considerable distance from his point of departure. This exhibition of gliding flight fairly startled the world, and henceforth the experiments of Lilienthal were conducted in the public eye. He made hundreds of successful flights with his gliding machine, varying its construction from time to time, and communicating to the world the results of his experiments with practical directions how to manage the machine under circumstances of difficulty; so that, when at last he met with the usual fate of his predecessors in this line, the experiments were not abandoned. They were continued in America by Chanute of Chicago, Herring, and other Americans, including the Wright brothers, of Dayton, Ohio.

Hargrave of Australia attacked the flying-machine problem from the standpoint of a kite, communicating his results to the Royal Society of New South Wales. It is to him we owe the modern form of kite known as the "Hargrave box kite," which surpasses in stability all previous forms of kites. He also constructed successful flying-machine models on a small scale, using a store of compressed air as his motive power. He did not attempt to construct a large-sized apparatus or to go up into the air himself; so he still lives, to carry on researches that are of interest and value to the world.

SUCCESSFUL FLIGHT OF PROF. LANGLEY'S MODEL.

No one has contributed more to the modern revival of interest in flying-machines of the heavier-than-air type than our own Prof. Langley, the late secretary of the Smithsonian Institution. The constant failures and disasters of the past had brought into disrepute the whole subject of aerial flight by man; and the would-be inventor or experimenter had to face not only the natural difficulties of his subject, but the ridicule of a skeptical world. To Prof. Langley is due the chief credit of placing this subject upon a scientific basis, and of practically originating what he termed the art of "aerodromics." In his epoch-making work on "Experiments in Aerodynamics," published in 1891 among the Smithsonian Contributions to Knowledge, he prepared the world for the recent advances in this art by announcing that:

"The mechanical sustention of heavy bodies in the air, combined with very great speeds, is not only possible, but within reach of mechanical means we actually possess."

He also attempted to reduce his principles to practice by the construction of a large model of an aerodrome driven through the air by a steam engine under the action of its own propellers. I was myself a witness of the memorable experiments made by Prof. Langley on the 6th of May, 1896, with this large-sized model, which had a spread of wing of about 14 feet. No one who witnessed the extraordinary spectacle of a steam-engine flying with wings in the air, like a great soaring bird, could doubt for one moment the practicability of mechanical flight. I was fortunate in securing a photograph of this machine in full flight in the air, so that an automatic record of the achievement exists. The experiment realized the utmost hopes and wishes of Prof. Langley at that time.

"I have brought to a close," he says, "the portion of the work which seemed to be specially mine—the demonstration of the practicability of mechanical flight; and for the next stage, which is the commercial and practical development of the idea, it is probable that the world may look to others. The world indeed will be supine if it does not realize that a new possibility has come to it, and that the great universal highway overhead is now soon to be opened."

But the world was not satisfied with this position. It looked to Prof. Langley himself to carry on the experiments to the point of actually transporting a human being through the air on an aerodrome like his model; and so, with the aid of an appropriation from the War Department of the United States, Prof. Langley actually constructed a full-sized aerodrome, and found a man brave enough to risk his life in the apparatus—Mr. Manley, of Washington, D. C.

LANGLEY'S EXPERIMENTS WITH HIS LARGE MACHINE.

Great public interest was aroused; but Prof. Langley did not feel justified in giving information to the public, and therefore to foreign nations, concerning experiments undertaken in the interests of the War Department. His own dislike to premature publicity co-operated with his conscientious scruples to lead him to deny the newspapers the opportunity of witnessing the experiments. But the newspapers insisted upon being represented. The correspondents flocked to the scene, and camped there for weeks, at considerable expense to their papers. They watched the house-boat containing the aerodrome by day and by night, and upon the least indication of activity within, newspaper reporters were on hand in boats. After long delay in hopes of securing privacy it was at last decided to try the apparatus; but the newspaper representatives, embittered by the attempts to exclude them, were bringing the experiments into public contempt. They nicknamed the apparatus "The Buzzard," and were all ready to presage defeat.

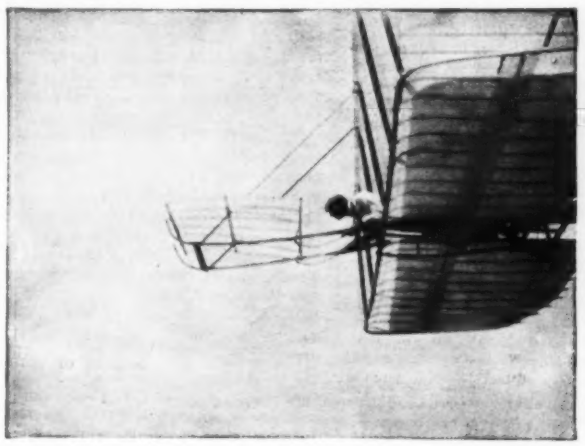
Two experiments were made; but on both occasions the apparatus caught in the launching ways and was precipitated into the water without having a chance to show what it could do in the air. The newspapers immediately announced to the world the failure of Prof. Langley's machine and ridiculed his efforts. The fact of the matter is that the machine was never tried, and that there was no more reason for declaring it a failure than for deciding that a ship would not float that has never been launched. After having witnessed the successful flight of the large-sized model of 1896, I have no doubt that Prof. Langley's full-sized aerodrome would have flown had it been safely launched into the air.

When the machine was for the second time precipitated into the water it was not much damaged by the accident. Prof. Langley, of course, was more anxious about the fate of his intrepid assistant than of his machine, and followed Mr. Manley into the house-boat to ascertain his condition. During this temporary withdrawal from the scene of the catastrophe the crew of a tugboat grappled the frail framework of the submerged aerodrome, and in the absence of any one competent to direct their efforts they broke the machine to pieces, thus ending the possibility of further experiments without the expenditure of much capital. The ridicule of the newspapers, however, effectually prevented Prof. Langley from securing further financial aid, and, indeed, broke his heart. There can be little doubt that the unjust treatment to which he was exposed contributed materially to the production of the illness that caused his death.

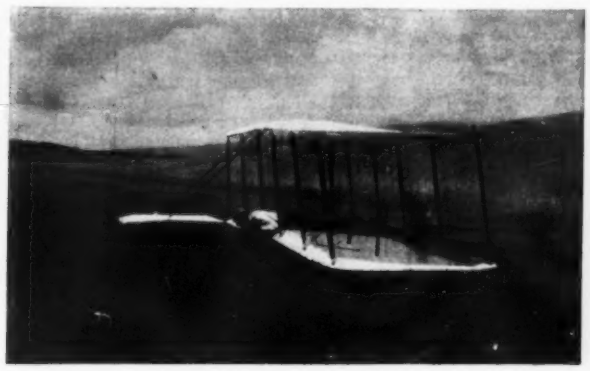
He lived long enough, however, to know of the complete fruition of his hopes by others, and only two days before his death he had the gratification of receiving a communication from the newly formed Aero Club of America recognizing and appreciating his efforts to promote mechanical flight.

THE FIRST PRACTICAL FLYING MACHINE.

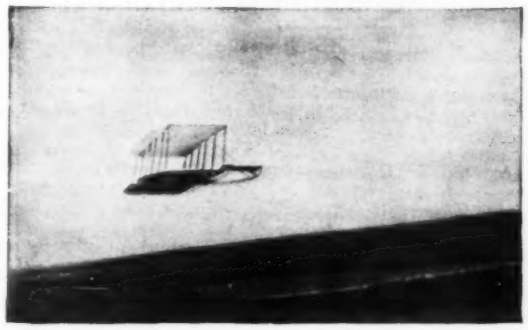
Both in the case of Lilienthal and Langley their efforts have not been in vain. Others have continued their researches, and to-day the world is in possession of the first practical flying machine, the creation of the brothers Orville and Wilbur Wright, of Dayton, Ohio. Indeed, we have news from France that a second has just appeared, constructed by the same Santos Dumont to whom the world already owes the first practical dirigible balloon.



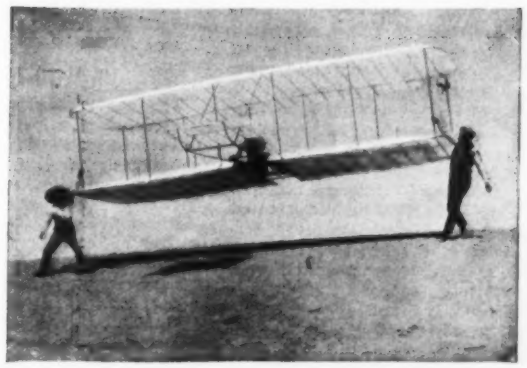
SOARING.



LANDING.



A HIGH GLIDE.



STARTING A FLIGHT.

From the National Geographic Magazine.

THE WRIGHT BROTHERS' GLIDING MACHINE

AERIAL LOCOMOTION.

The Wright brothers began by repeating the gliding experiments of Lilienthal, with improved apparatus of the Hargrave type as modified by Chanute. After having made many successful glides through the air without a motor, they followed in the footsteps of Langley, and propelled their machine by means of twin screws operated by engine power. They were successful in launching their apparatus into the air, and it flew, carrying one of them with it. Their machine has flown not once simply, but many times, and in the presence of witnesses; so that there can be no doubt that the first successful flying machine has at last appeared. Specially successful flights were made on the 3d and 4th of October, 1905, which were referred to by the Wright brothers in a letter to the editor of L'Aerophile, published in that journal January, 1906. They have also made a communication upon the subject to the Aero Club of America, and have received the formal congratulations of that organization upon their success.

Each of the Wright brothers in turn has made numerous flights over their testing field near Dayton, Ohio, sometimes at an elevation of about 80 feet; at other times skimming over the field at a height of about ten feet from the ground. They have been able to circle over the field of operation, and even to describe in the air the figure eight, thus demonstrating their perfect control over their apparatus, both in the vertical and horizontal directions. They have succeeded in remaining continuously in the air for more than half an hour—thirty-eight minutes, in fact—and only came down on account of the exhaustion of their fuel supply. They state that the velocity attained was one kilometer per minute, or about thirty-seven miles an hour. The machine has not only sustained its own weight in the air during these trials, but has also carried a man and a gasoline engine weighing 240 pounds, exerting a force of from 12 to 15 horse-power, and in addition an extra load of 50 pounds of pig-iron. The apparatus complete, with motor, weighed no less than 925 pounds, while the supporting surfaces consisted of two superposed aeroplanes each measuring six by forty feet; so that the machine as a whole had a flying weight of nearly two pounds per square foot (1.9 pounds).

Thanks to the efforts of the Wright brothers, the practicability of aerial flight by man is no longer problematical. We can no longer consider as impossible that which has already been accomplished. America may well feel proud of the fact that the problem has been first solved by citizens of the United States.

A FEW NOTES OF PROGRESS IN THE CONSTRUCTION OF AN AERODROME.

For many years past—in fact, from my boyhood—the subject of aerial flight has had a great fascination for me. Before the year 1896 I had made many thousands of still unpublished experiments having a bearing upon the subject, and I was therefore much interested in the researches of Prof. Langley relating to aerodynamics. We were thrown closely together in Washington, and although we rarely conversed upon aerodynamics we knew that we had a subject of mutual interest and showed the greatest personal confidence in one another. I did not hesitate to show him my experiments; he did not hesitate to show me his. At least as early as 1894 Prof. Langley visited me in my Nova Scotia home and witnessed some of my experiments; and in May, 1896, he reciprocated by inviting me to accompany him to Quantico, Virginia, and witness a trial of his large-sized model. The sight of Langley's steam aerodrome circling in the sky convinced me that the age of the flying-machine was at hand. Encouraged and stimulated by this remarkable exhibition of success, I quietly continued my experiments in my Nova Scotia laboratory in the hope that I, too, might be able to contribute something of value to the world's knowledge of this important subject.

Warned by the experiences of others, I have sought for a safe method of approach—a method that should risk human life as little as possible during the earlier stages of experiment. Experiments with aerodromes must necessarily be fraught with danger until man, by practical experience of the conditions to be met with in the air and of the means of overcoming them, shall have attained skill in the control of aerial apparatus. A man cannot even ride a bicycle without practice, and the birds themselves have to learn to fly. Man, not having any inherited instincts to help him in this matter, must first control his flight consciously, guided by knowledge gained through experiment. Skill can only be obtained by actual experience in the air, and this experience will involve accidents and disasters of various sorts before skill can be obtained. If these disasters should, as so often in the past, prove fatal to the experimenter, the knowledge obtained by the would-be aviator will be lost to the world, and others must begin all over again, instead of pursuing the subject where he left off, with the benefit of his knowledge and his experience. It is therefore of the utmost consequence to so progress in the art of aviation that the first attempts to gain experience in the air should be made under such conditions of safety as to reduce to a minimum the liability to fatal results.

(To be continued.)

Etching Fluid for Copper, Steel, and Zinc Plates.—Four parts of pure concentrated acetic acid, 1 part of absolute alcohol, and 1 part of nitric acid. The alcohol and acetic acid are mixed, and after the lapse of half an hour the nitric acid is added.

SCHOOLS OF AIRSHIP INSTRUCTION IN GERMANY AND FRANCE.

ALL arrangements have now been perfected for the opening of the new school at Chemnitz, Germany, on May 1, 1907. The authorities of Chemnitz have given their official approval of the institution and of its curriculum of studies. The director, Herr Paul Spiegel, is a man of exceptional ability and of broad experience in every phase of balloon construction and management. He has made over 600 ascents. He has done much by public lectures and otherwise to awaken interest in aerial navigation in various parts of Germany, but especially in Chemnitz, where he is well known as a textile manufacturer. Recently he has enlarged his business so as to include the regular manufacture of balloons.

This city is unquestionably most admirably adapted for the location of the proposed school, as it is a leading center for the manufacture of engines, motors, etc. Its importance as a textile center comes likewise into consideration. In industrial circles it is confidently expected that with the aid of the new institution and as a result of the widespread interest in aeronautics already existing in this city, Chemnitz may be easily made the chief place in Germany for the manufacture of airships, both of the balloon and the aeroplane type.

On May 1, 1907, an institute will be opened at Chemnitz for theoretical and practical training in the construction and management of airships. Young men at least 16 years of age will have for the first time in Germany the opportunity to master all features of aeronautics. Rapid progress has been made during the past few years in perfecting the means for aerial locomotion. Aeronautics has rendered admirable service to science, military operations, and sport. At an early date it will certainly reach a high stage of development and create a prominent branch of industry. For this reason it is important to train at once such young men as have a special inclination for this new branch, so that they may gain a sufficient capital of theoretical knowledge and practical experience to meet the forthcoming demands both in the construction and in the management of aerial craft.

An airship offers to its passengers delights unsurpassed by any other method of travel and places at the service of the lover of nature the grandest experiences that life on our planet affords.

The director of the institute has been an active aeronaut for the past twenty-six years. As the result of many hundred balloon ascents and by long experience in the construction of all forms of balloons he has gained that complete mastery of the subject requisite for successful instruction.

A valuable opportunity is offered young men who purpose later to enter the aeronautic corps of the army.

In view of the exceptional expense attendant upon such a course of instruction, more particularly the cost of the frequent inflation of balloons, the tuition charge for a year's course has been fixed at 600 marks ($149), the same to be paid in monthly installments and in advance.

The course begins on May 1 and terminates on April 30.

An examination is held at the close and certificates of proficiency are granted.

CURRICULUM.

Division I.—(1) Calculation of volumes; (2) the cutting of the materials of a balloon; (3) preparation of impermeable fabrics; (4) construction of nets; (5) safety valves; (6) lectures on the theory of aerial navigation.

Division II.—(1) Inflation of balloons: (2) ascent of passengers; (3) physical instruments employed; (4) meteorological observations; (5) independent management of a balloon; (6) lectures on the problems of aerial navigation, dirigible balloons, aeroplanes, and motors.

As is evident from the above schedule, study and practical training will be confined almost exclusively to the field of balloon construction and navigation.

In view of the rapid development in the construction of aeroplanes it is a question whether the non-dirigible balloon will be in any extended use ten or twenty years hence. However that may be, there is no doubt that the time is ripe for the training of a class of men familiar with the problems of aerial navigation, accustomed to traverse the air with boldness and confidence, and meet promptly and effectively the emergencies and accidents which are incident to practical aeronautics. For the training of such a class of persons, few men are probably as well adapted as the director of the new school, who seems to combine the requisite extended experience with a degree of mingled courage and prudence, quick adaptation to emergencies, practical inventive ability, and, above all, enthusiasm and unwavering confidence in the early and complete conquest of the air.

FRANCE.

Consul-General Frank H. Mason, of Paris, furnished the following report on the progress being made in France in the training of aeronauts and construction of balloons:

There is in France, strictly speaking, no school for the training of aeronauts and constructors of airships in which a definite and prescribed course of study or lectures is pursued. Such instruction and practice in aerostation as are offered here are provided by clubs and by the government in connection with the military service. There are in Paris four rather important aeronautical societies or ballooning clubs, and five similar organizations elsewhere in France. These clubs were created for the promotion and practice of ballooning as a sport as well as for scientific study and experiment and in general for the encouragement of all that pertains to aerostation.

In some of these young men are given practical training, taught the theory of construction and use of balloons, and instructed practically concerning balloon materials and parts, such as the net, anchor, basket, the guide rope, valves, the tying of ropes, knots, etc., the preparation of the balloon for an ascension, and the care and return of the material after descending. Under certain circumstances these pupils—who are always members of the club—may take part in the ascensions, learn how to handle the balloon in the air, and descend under different conditions of daylight and weather. If they acquire a certain efficiency in all this and pass a prescribed examination, they are permitted, when drawn for military service, to enter the Bataillon d'Aerostiers, or balloon corps of the army. This battalion is established in what is known as the "Menagerie," the old zoological garden formerly belonging to the palace and park at Versailles and located between that city and the military school at St. Cyr. Formerly these corps, Bataillons d'Aerostiers, were distributed among several points in the provinces, but since 1870 the government has concentrated them at the "Menagerie," and they form part of the regiment of engineers garrisoned at Versailles.

The post is under the control of a commandant, and the men are taught and practise the handling and care of balloons, of which there are in use several of moderate size, none with a capacity exceeding 900 cubic meters. Besides the balloons, the apparatus, and material necessary for inflating them, the equipment includes a plant for making hydrogen gas, which was formerly exclusively used for inflation, but more recently illuminating gas, on account of its more moderate cost, has been generally employed, especially for free ascensions. Most of the ascensions made there are with captive balloons.

The men who enter this branch of the service are trained at the annual maneuvers for active duty in case of war. Their teaching is practical, and includes all that pertains to preparing, loading, unloading, inflating, deflating, packing up, transporting, camping an inflated balloon in bad weather, etc., but they make no ascensions. This is the exclusive duty of officers. Their service lasts ordinarily two years, when they are discharged, subject for call to duty in the military balloon corps in case of war. The main incentive to service at the "Menagerie" is that it offers a less arduous form of duty than ordinary service in the ranks, and moreover keeps the young recruit within convenient distance of Paris; but many of the young men have no special gift for the management of a balloon, and opinion among experts is somewhat divided as to whether most of them learn much that would really be available in the event of actual war occurring.

The second and far more important institution of this kind in France is known as the "Etablissement Central du Matériel de l'Aerostation Militaire," at Chalais-Meudon, about midway between Paris and Versailles. It has been in existence nearly a hundred years, and is divided into two general departments, as follows:

1. The Arsenal, at present under the command of Commandant Bouttiaux, at which are manufactured balloons and every form of balloon material and equipment for use of the aeronautic service of the French army.

2. The Department of Tests and Experiments, under command of Lieutenant-Colonel Bertrand, where new inventions are developed and tests made with gas and every form of material and appliance which pertains to military aeronautics.

The institution is in fact a combined arsenal and experiment station, but it is in no proper sense a school, since it has no definite course of instruction, no text-books or specified course of lectures. It is there that the official experiments in aerostation, tests of new materials and original features in construction are made by military experts. It was there that Col. Renard twenty-three years ago built and experimented with "La France," the first dirigible balloon. These two institutions, the "Menagerie" training camp near St. Cyr, and the arsenal at Chalais, are the two principal government stations for balloon materials in the neighborhood of Paris. There are, besides, several minor depots of such material at military posts near the frontiers, where it would be promptly available in case of war. It is, moreover, known that two of the French army corps are provided with large dirigible balloons of the Lebaudy type, built for the purpose by the Lebaudy brothers, who also trained at their works the first soldiers who were instructed in inflating and navigating them.

Paris is the central mart of balloon construction in Europe. The leading builders are Maurice Mallet, with ateliers at Puteaux, who made most of the balloons which took part in the international race of 1906, and supplied two balloons to the United States government during the Spanish-American war; E. Surcouf, at Billancourt, who built the first Lebaudy airship; H. Lachambre, who is the constructor of the several airships of Santos Dumont, and Louis Godard, constructor of the Wellman airship which will endeavor to reach the North Pole. At present the preparation of material for the Wellman Arctic expedition is in charge of an American engineer, Mr. Melvin Vaniman, of Indiana.

[Concluded from SUPPLEMENT No. 1637, page 26227.]

THE INFLUENCE OF PHYSICAL CONDITIONS IN THE GENESIS OF SPECIES.*

By JOEL A. ALLEN.

THE direct influence of climatic or geographical conditions upon animals is, in the main, ignored by the leading exponents of the doctrine of natural selection. To quote Mr. Darwin's own words on this point:

"The action of climate seems at first sight to be quite independent of the struggle for existence; but, in so far as climate chiefly acts in reducing food, it brings on the most severe struggle between the individuals, whether of the same or of distinct species, which subsist on the same kind of food. Even when climate—for instance, extreme cold—acts directly, it will be the least vigorous, or those which have got the least food through the advancing winter, which will suffer most. When we travel from south to north or from a damp region to a dry, we invariably see some species gradually getting rarer and rarer and finally disappearing, and the change of climate becoming conspicuous, we are tempted to attribute the whole effect to its direct action. But this is a false view; we forget that each species, even where it most abounds, is constantly suffering enormous destruction at some period of its life from enemies or from competitors for the same place and food, and, if these enemies or competitors be in the least degree favored by any slight change of climate, they will increase in numbers, and, as each area is already fully stocked with inhabitants, the other species will decrease. When we travel southward and see a species decreasing in numbers, we may feel sure that the cause lies quite as much in other species being favored as in this one being hurt. So it is when we travel northward, but in a somewhat lesser degree, for the number of species of all kinds, and therefore of competitors, decreases northward; hence in going northward or in ascending a mountain we far oftener meet with stunted forms due to the *directly* injurious action of climate than we do in proceeding southward or in descending a mountain. When we reach the Arctic regions or snow-capped summits or absolute deserts, the struggle for life is almost exclusively with the elements. That climate acts in main part indirectly by favoring other species we may clearly see in the prodigious number of plants in our gardens which can perfectly well endure our climate, but which never become naturalized, for they can not compete with our native plants nor resist destruction by our native animals."[7]

While there is perhaps little reason to question the general correctness of the above-quoted generalizations, they have little bearing upon the question of the modification of species by the direct action of climatic conditions, but relate mainly to such unfavorable climatic influences as tend toward the extinction of species or to the circumscription of their ranges. Indeed, the phenomena of variation detailed in the foregoing pages were almost wholly unknown at the time the earlier editions of the Origin of Species were published, and have hardly as yet become the common property of naturalists. Gradual decrease in size southward in hundreds of species inhabiting the same continent, or a gradual increase or decrease in color in given directions on a similarly grand scale, are facts but recently made known, and have not as yet been very fully discussed by evolutionists of the purely Darwinian school. Mr. Darwin, indeed, in referring to the "effects of changed conditions" upon animals, alludes to facts of a similar character—as the alleged brighter colors of European shells near their southern limit of distribution and when living in shallow water, and the more somber tints of birds that live on islands or near the coast under overcast skies as compared with those of the same species living more in the interior, etc.—but is in doubt as to how much should be attributed even in such cases "to the accumulative action of natural selection and how much to the definite action of the conditions of life." "Thus," he says, "it is well known to furriers that animals of the same species have thicker and better fur the farther north they live; but who can tell how much of this difference may be due to the warmest-clad individuals having been favored and preserved during many generations and how much to the action of the severe climate? For it would appear that climate has some direct action on the hair of our domestic quadrupeds."[8] Since, however, it happens that some species do not vary at all, although living under the most opposite climates, he is thereby inclined "not to lay much weight on the direct and definite action of the conditions of life," though he fully admits that "strong arguments of a general nature may be advanced on the other side." "In one sense," he adds, "the conditions of life may be said not only to cause variability, but likewise to include natural selection, for the conditions determine whether this or that variety shall survive."[9] But he says again: "I believe that natural selection generally acts slowly in effecting changes *at long intervals of time and only on a few of the inhabitants of the same region.*" In a later work, however, he refers to the variation in color with locality seen in many species of birds in the United States, and says explicitly, in reference to northern and southern localities, "this seems to be the direct result of the difference in temperature, light, etc., between the two regions."[10]

There is, however, a vast amount of unquestionable proof of the direct and constant action of climate and other conditions of life upon animals, and that such geographical variations as the thicker and softer fur of mammals inhabiting cold regions, smaller size and brighter colors at the southward, etc., do not require the action of natural selection, in its strict and proper sense, for their explanation. It is well known, for instance, that a flock of fine-wooled sheep when taken to a hot climate rapidly acquire a coarser and coarser fleece, till, in a few generations, it nearly loses its character of proper wool, and becomes simply hair; that the change affects simultaneously the whole flock, and is not brought about by one or two individuals acquiring a coarser fleece and through their descendants modifying the character of the herd. Furthermore, in the case of sheep, it is well known that certain countries are very favorable to the production of a fine fleece, and that fine-wooled breeds, even by man's aid, can not be perpetuated in other regions. Again, it is a fact of common observation that in birds and mammals colors become more or less faded toward the moulting season simply by the direct action of the elements, the tints of the fresh and the long-worn plumage or pelage being more or less strikingly different in the same individuals, and that this contrast at different seasons is more marked in arid than in moist regions, through the greater bleaching effect of a dry heated atmosphere and the more intense dazzling sunlight of regions that are not only cloudless, but lack the protection afforded by abundant vegetation.

While so much is claimed by the writer as due to the direct action of climatic causes, it is admitted also that habits and food and other conditions of life than those resulting from climate have a marked effect in determining modifications of form and color among animals. A scarcity of a favorite kind of food will undoubtedly force species to subsist upon the next best that offers, which may be so different as to modify certain characters and fit the species to live upon the less desired food. A change of food may lead to modification of dentition, the muscles of mastication, and the organs of digestion and, correlatively, of other organs or parts of the body; the modification, however, arising simultaneously among all the descendants of the individuals thus driven to a change of diet, instead of appearing first in a single individual and becoming perpetuated in its descendants alone. Entomologists have found that, among insects of the same species, the forced or voluntary use of different food plants gives rise to modifications of color and structure, and hence result in what have been termed phytophagic varieties or subspecies, and that man can also effect such changes at will by simply changing the food of the species. Again, the geological character of a country is well known to have a marked effect upon the size and color of animals inhabiting it, as is strikingly illustrated among molluscous animals, whose abundance, and even presence, is largely dependent upon the constituents of the soil. Over regions of the United States, for example, where the underlying rock is noncalcareous the species are both few in number and sparsely represented, while in other regions, where limestone abounds but which are in other respects essentially the same, the species are far more numerous and far more abundantly represented. In respect to the fresh-water mussels, those of the same species from different streams are easily distinguishable by differences in the thickness of the shell, in color, shape, and ornamentation, so that the character of the shells themselves affords a clew to the locality of their origin. At some localities the species tend to become tuberculous or spinous, this being particularly the case toward the southward; at other localities they acquire a very much thickened shell, or different colors, the same characteristics appearing simultaneously in quite diverse species, and thus becoming distinctive of particular localities. In regard to mammals, measurements of large series of the skulls of minks, martens, squirrels, and other native species show that the representatives of these species living in northern New England and northeastern New York are smaller than the representatives of the same species occurring in the limestone districts of Pennsylvania and the States more to the westward, and the same is true of the different kinds of domestic cattle. This is in opposition to the law of decrease in size southward that elsewhere and generally characterizes these same species, and seems obviously related to the geological character of the country at these localities; small size, in opposition to a general law, occurring over northern noncalcareous districts, and larger size more to the southward, where the underlying rock is limestone. In this case the difference obviously results from the direct action of the conditions of habitat upon every individual rather than from "slowly effected changes" originating in "only a few of the inhabitants" of these respective districts.

Use and disuse of organs, through changes of habit resulting from changed conditions of environment, must result in some modification of the organ involved. As an example may doubtless be cited the passerine birds of some of the smaller, remotely situated islands, as the Guadeloupe and Galapagos groups, where recent investigations have shown that most of the species differ similarly in several features from their nearest allies of the mainland, and of which they are unquestionably insular forms. These differences consist in the greater size of the bill, shorter wings, longer tails, and darker colors. The sedentary life necessitated by the confined habitats of species thus situated would naturally act more or less strongly on the organs of flight, and a reduction in the size of the wing would follow, not necessarily through the roundabout process of natural selection, through the modification originally of a single individual, but by the direct action on all the individuals alike of the changed conditions of life.

It is doubtless unnecessary to further multiply examples of the modification of animals by the direct action of the conditions of life. The subject is one that can be but imperfectly treated at best in a short paper like the present. The illustrations have here been drawn from a limited geographical field and mainly from among the two higher classes of vertebrates. There are, however, abundant indications that other fields and other classes would yield results equally confirmatory of the direct action of physical conditions in the evolution of specific forms among animals and plants. Changes in environing conditions will, however, go but a short way toward explaining the origin of the great diversity of structure among existing organisms; the character of the food, habit, or the increased use or the disuse of particular organs may explain many of the modifications, leaving a large share of the work to as yet unknown causes. Natural selection, as sometimes defined, is made to cover all causes of differentiation, it being stated by Mr. Darwin himself that if organic beings undergo modification through changes in their conditions of life "uniformity of character can be given to their modified offspring solely by natural selection preserving similar favorable variations." In its strict sense, variation by natural selection results only through favorable differences appearing at first in single isolated individuals, which transmit these favorable qualities to their offspring, in virtue of which they multiply till they outnumber, crowd out, and finally destroy the less-favored form from which they originated.

It is hardly conceivable, for example, how the peculiar structure seen in the woodpecker, the kingfisher, the swift, the heron, or the duck, or the peculiar dentition and correlated characters of the rodents, the ruminants, or the shrews and moles, as compared with the carnivora, can have been initiated by the direct action of climatic conditions, however much other conditions of environment may have favored the development of these diverse types.

Having thus far mainly detailed merely facts and coincidences relating to the subject of variation with locality, it may be well in conclusion to consider more fully some of the possible or probable causes of purely geographical variation. In regard to geographical variation in color, it seems evident that high temperature, conjoined with moisture, favors increase of color, and especially the acquisition of lustrous tints, while moisture alone favors simply increase in depth or the production of dull, heavy, and especially fuscous phases of coloration; on the other hand, that aridity and exposure favor the loss of color. The latter is due apparently no less to the influence of a dry and often intensely heated atmosphere than to the direct action of light intensified by the reflection of the sun's rays from almost verdureless sands. That the latter conditions act powerfully in blanching color there is most abundant proof. Hence we have the necessary correlation of increase of bright rich tints of coloration with the increase of atmospheric humidity. In respect to the enlargement of peripheral parts at the southward, it is obvious that a high temperature favors the more rapid circulation of the blood in these parts, while, as is well known, a low temperature produces the opposite effect and necessarily retards their development.

With the decrease in size among birds, there has been observed a decrease of vivacity and deterioration of song, which may reasonably be attributed to the enervating influence of a high temperature. Since the northern types of animals reach their highest physical development toward the northward, it seems fair to suppose that decrease in size southward may be directly due to the enfeebling influences of increase of temperature, since certainly it can not be attributed, in the majority of cases at least, to greater scarcity of food, for in many instances just the reverse obtains. This supposition is in accordance with the known effects of similar climatic conditions upon the northern races of man, which reach their greatest vigor and highest intellectual status under temperate conditions of climate, and deteriorate, both physically and mentally, on removing to intertropical regions. Again, the mammals and birds of the United States reach their maximum size within the United States under the stimulating climate of the region drained by the upper Mississippi and upper Missouri rivers, being, as a rule, larger here than in corresponding latitudes more to the eastward. The decrease in size toward both the northern and southern borders of the habitat of a given species or genus, of which there are many marked instances, further shows that size varies with the varying conditions of habitat and reaches the maximum only where the conditions are most favorable to the life of the species.

Much has been written respecting the influence of climate on man, and many speculations have been indulged in in relation to the part the conditions of life have taken in bringing about the diversity at present existing among the different races. A striking parallelism is often observable between the leading features of geographical variation among animals and the physical differences that obtain among nations or races of men inhabiting the same areas and subjected to the same influences. While civilized man is, in a measure, less the subject of such influences than the lower animals, he is not wholly above them. Certain regions more favor both physical and intellectual de-

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* Reprinted, with note and bracketed additions by the author, from the Smithsonian Institution's Report.

[7] Origin of Species, 5th ed., pp. 80, 81.

[8] Origin of Species, pp. 166, 167.

[9] Origin of Species, p. 168.

[10] The Descent of Man, 2d ed., p. 225.

velopment than others, and these prove to be, as would be expected, the milder temperate portions of the globe, where the struggle for a mere vegetative existence is reduced to a minimum.

The influence of different climatic conditions upon members of the same nationality finds exemplification in different parts of our own country, and are so obvious as to be the subject of frequent observation and comment. The same original stock is found to gradually develop certain peculiar physical and mental characteristics when placed under diverse conditions of climate, certain localities more favoring intellectual growth and activity than others, just as certain regions are characterized by the frequent occurrence of particular diseases which in other regions are exceptional. While humidity and a high temperature, when combined, are found to be enervating and deteriorating, a clear, dry atmosphere favors vigor of both mind and body. But the subject of the influence of climatic conditions upon man is too vast to be entered upon in detail in the present connection. The study of man from a geographical standpoint, or with special reference to conditions of environment, offers a most important and fruitful field of research, which, it is to be hoped, will soon receive more careful attention than has as yet been given it.

In conclusion, a few words seem called for concerning the question, What is a species? as well as in respect to the bearing of the general facts above detailed upon the evolution of specific forms.

As is well known, the belief that species were distinct and immutable creations was long the prevailing one among naturalists. Yet the question of what constitutes a species is one about which endless discussions have arisen, and one respecting which the most discordant opinions have been held by naturalists equally eminent in their respective fields of research. The amount and kind of difference necessary to characterize a species has been variously defined; forms that some have considered as specific others have regarded as merely varieties, and the reverse. In certain groups of organisms intermediate forms have been constantly met with, constituting steps of easy intergradation between quite diverse types. Such forms have been and still are held by some writers as varieties of a single species and by others as constituting a group (genus or subgenus) of distinct but nearly related species. Through the frequent discovery of such intergradations, however, the instability of so-called "species" has been made manifest and the contrary doctrine of the stability or fixity of species refuted. Indeed, naturalists now generally agree that the terms "variety," "species," "genus," "subgenus," "family," "subfamily," "superfamily," and the like, are but conventional and more or less arbitrary designations for different degrees of differentiation—convenient formulæ for the expression of general facts in biology. Not a few high authorities even maintain that the differences which characterize these several groups are of the same nature, differing only in degree, in opposition to others who hold that they are based on different categories of structure, or on differences of *kind* rather than of degree. The falsity of the latter view is shown more and more clearly with the increase of our knowledge of the structure and affinities of animals.

While formerly species were considered as necessarily characterized either by differences of a particular kind, or by a certain amount of difference, the present tendency is to regard neither as a sufficient criterion, the test of specific diversity being merely absence of intergradation, in other words, breaks in the continuity of closely allied beings. Local races, or geographical forms, are thrown together under one specific designation whenever they are found to intergrade, however diverse may be their extreme phases of differentiation. The term species is now made to cover groups which were, not many years since, frequently regarded as subgenera, or even genera, the forms then supposed, in numberless instances, to be "good species," now ranking merely as subspecies. The reduction in the number of species has necessarily entailed a considerable reduction in the number of currently accepted genera, which in turn are limited by hiati rather than by any given amount or particular kind of difference. It was formerly urged against the theory of evolution that its advocates could point to no instance of the gradual change of one species into another, and that, until this was done, the theory was untenable. Among the species of North American vertebrates recognized as valid ten years ago, hundreds of instances can now be cited of thoroughly proven intergradation, forms then regarded as unquestionable species being found to be but connected phases of one and the same specific type, which assumes, at remote localities, under the evident action of climatic agencies, phases widely diverse, which gradually merge the one into the other through the individuals inhabiting the intervening districts. So long as species are based on the absence of intergradation, and biologists have found no other satisfactory criterion for their limitation, there can of course be no passage of one species into another. Let, however, some of the connecting links become extinct, and these now intergrading forms would be resolved into distinct species. In this way insular and other local forms are passing beyond the so-called varietal stage, and species are similarly tending to generic distinctness. That varieties may and do arise by the action of climatic influences, and pass on to become species, and that species become, in like manner, differentiated into genera, is abundantly indicated by the facts of geographical distribution and the obvious relation of local forms to the conditions of environment. The present more or less unstable condition of the circumstances surrounding organic beings, together with the known mutations of climate our planet has undergone in past geological ages, points clearly to the agency of physical conditions as one of the chief factors in the evolution of new forms of life. So long as the environing conditions remain stable, just so long will permanency of character be maintained; but let changes occur, however gradual or minute, and differentiation begins. If too sudden or too great, extinction of many forms must result, giving rise to breaks in the chain of genetically connected organisms. In the deep abysses of the sea, where the temperature is low and stable, where the conditions of life must have remained almost unvaried since the early geological periods, the same low organisms still exist that were the prevailing forms of life when life first dawned upon the earth. The recent explorations of the depths of the sea have gone far to prove that stability of organic forms is in direct ratio to the stability of the conditions of existence, while the facts of geographical distribution show that change of structure and diversity of life are directly related to the physical conditions of habitat.

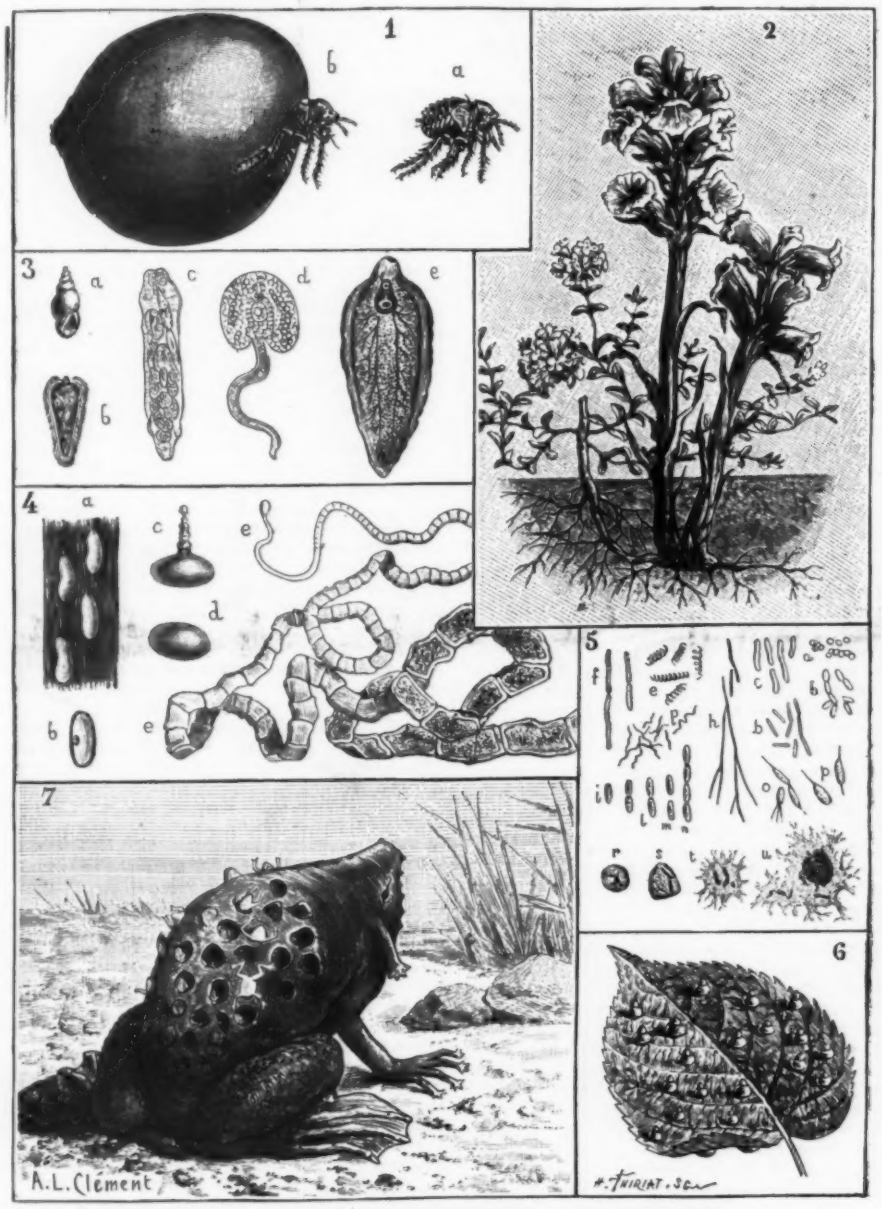


FIG. 1.—DIFFERENT PHENOMENA OF PARASITISM.

1. The Chigoe (*Pulex penetrans*) differentiated into a large female, *b*, and a small male, *a*. 2. *Orobanche*, a phœnogamous plant degraded by parasitism. 3. Successive phases of *Distomum hepaticum* (liver fluke); *a*, *Lymnea* into the interior of which the infusoriform embryo, *b*, enters, and which is transformed into a sack (*sporocyst*) *c*, filled with *rediæ*, *d*, which at maturity gives in turn embryo *b*. 4. The same history with a *Tænia*; *a*, *cysticercus* in the muscles of a hog or ox; *b*, the same isolated; *c*, the same with the head projecting from its sheath; *d*, egg with embryo; *e*, adult tapeworm of man. 5. Different microbian forms; *a*, micrococcus; *b*, bacteria; *c*, vibrio; *d*, bacillus; *e*, sprochæta; *f*, leptotrichus; *g*, spirillus. 6. Poplar leaf with galls. 7. The toad *Pipa dorsigera* with its parasitic progeny.

NOTE.—During the twenty-nine years that have passed since the original publication of this article great advances have been made in our knowledge of the mammals and birds of North America, to which this paper primarily relates. Nearly every part of the continent has since been explored in great detail by well-trained collectors, employing new methods and greatly improved devices, especially for the capture of the smaller rodents and insectivores, which in the earlier days proved so elusive. With the consequent immense increase of material, of much better quality and from innumerable localities, the point of view in regard to species and subspecies has greatly changed, resulting in changes of nomenclature. Aside from the technical names there is little in the article that I should modify were it to be now rewritten. All that it contains concerning geographic and climatic variation, and the influence of physical conditions in the genesis of species and subspecies, is still satisfactory. In the present reprint, the only changes found really desirable consist in the correction of a few typographical errors, and modifications here and there of technical names, to bring them more nearly in harmony with present nomenclature. These changes are for the most made in footnotes or by words inserted in brackets.

J. A. ALLEN.

American Museum of Natural History, New York city, February 1, 1906.

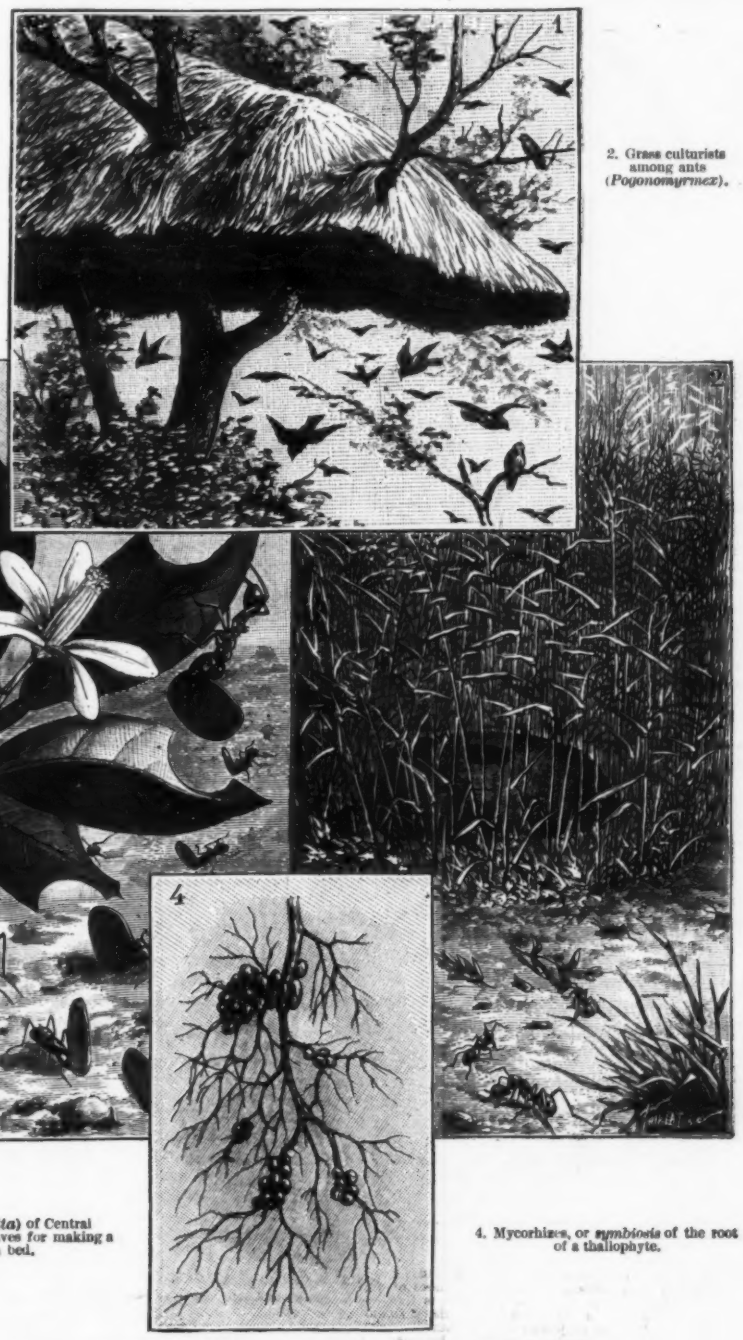
PARASITISM AND MUTUALISM.

IN a recent article published in La Nature we showed what sort of a relation exists between the various forms of life and the aquatic environment in which such forms are destined to develop and obtain nourishment. We saw that living types belonging to the same somewhat strictly limited *ensemble* (mollusks, for example) exhibit different characters according as they are examined in strongly saline, brackish, or fresh water. There is, therefore, a variation, a transformation of living forms parallel with the variations and transformations of their aquatic environment. Now, as the anatomical character of fresh-water animals and the history of their individual development present a great number of reminders of ancestors that lived in salt water, and as paleontology shows that the ancestors of the present forms appeared in the sea, we admit logically that the beings which now inhabit fresh water are but the modified descendants of beings that formerly lived in the sea.

The principal factor of such transformation, of which we, following the learned M. Pelseneer, endeavored to show the action, was the degree of salinity of the water, which, as we stated, was of special importance by reason of its physical action. We had not then to concern ourselves with seeking other causes of the modification of living forms. Such factors nevertheless exist and are very numerous. Just as we saw life vary with the conditions of salinity, just so would we have been able to indicate analogous facts for the variations of light and heat or of the different states of the water or air considered in their relations with living organisms.

It has been possible, for example, to distinguish plants and animals by the manner in which they react

under the action of light, the former presenting chlorophyl in most cases, and the latter a visual apparatus, that is to say, two things which are a direct intermedium between the sun and living nature. There also have been studied the effects of the complete or partial absence of light, which has been made to intervene as the chief factor in the formation of the characters which distinguish the faunas of great ocean depths, caverns, etc. In like manner has been studied the action of heat and shown the different manner in which animals resist the modifications that it may undergo; and such study has led to verifications and to the use of terms very much like those which we made known in a former article on the subject of eury- and stenohalin types. What have been called eurytherms are organisms capable of enduring great variations in temperature, and stenotherms those which, on the contrary, are submitted strictly to determinate thermic conditions. Water, of which we have already had occasion to speak, has been regarded now from the viewpoint of the variations in chemistry, and



1. Collective organization of property among "republican" birds (*Philaterus socius*) of South America.

2. Grass culturists among ants (*Pogonomyrmex*).

3. Parasol ants (*Atta*) of Central America collecting leaves for making a mushroom bed.

4. Mycorhizæ, or *symbiosis* of the root of a thallophyte.

FIG. 2.—DIFFERENT PHENOMENA OF MUTUALISM.

entirety of what is dead; and every variation in the inanimate world has its echo in the animate world. Light, heat, air, and water are the eternal laborers in this daily and secular task, and, while in the course of ages, the physiognomy of the earth becomes transformed, that of life undergoes a parallel evolution.

Nevertheless, the modifications of life, as they are revealed by observation of the past and present, have not as sole causes those of which we have just rapidly sketched the picture. Along with the action of the inanimate world, we must, in fact, in order to understand many biological phenomena, cause, in addition the intervention of the action of the animate world upon itself, that is to say, that of living beings upon their like. We may place ourselves at two points of view for the study of such action of living beings on each other, either as we consider the relations of individuals or groups of individuals belonging to the same species, or as we stick to the relations of species to species. The first point of view is that of *sociology*, the study of societies human as well as animal and

now from that of its physical state, considered now in a state of rest, in small areas or in vast extents, and now in a state of motion and operating by mechanical action solely. This study itself has also shown, for every variation in the environment, a considerable number of adaptations representing so many modifications in the form of living matter. Air in a state of rest or motion, acting now by the gases that it holds in suspension, and now by its mechanical operation, has not revealed itself as a factor of the least importance in the external modeling of life.

Thus, living beings do not appear to us as isolated in the environment of nature. A sculptor may be slow in bringing his work near to what he conceives as perfection. Some day, however, the statue will become strange to him—and will be finished. Creation, on its part, has never finished. It incessantly works over again the admirable forms with which it has been pleased to animate the gloom or the beauty of our landscapes. The most intimate relation unites, at every instant, the entirety of what is living with the even plant, and second is that of *ethology*. These are two domains which are equally curious and which teem with suggestive facts for reflective and observing minds.

We should like to give here a general idea of the instruction afforded by an ethological study of the animate world, and we could not do better in such an *exposé* than to allow ourselves to be guided by an excellent work, of a popular character and replete with erudition, just published by Dr. Laloy, on what he calls "Parasitism and Mutualism in Nature," synthetizing in these two formulas, borrowed from the vocabulary of human societies, two of the principal relations that exist either between individuals or between species.

The great question is to live, and the means of doing so is to eat. The relations of being to being and of species to species are dominated by this necessity for food, the immediate preoccupation, scarcely masked by sentimentalism among men, but entirely naked in the rest of the world. In order to find food, animals devour or aid one another; in short, they all live at the expense of one another; for it is well to point out the fact that parasitism and mutualism are not two essentially different things in the living world, but two extreme realizations of the same thing, the exploitation of others. Moreover, it must be remarked too, once for all, that it is not necessary to suppose, any more than in human societies, a conscient pact, a social contract, at the base of the relations of species. They may be considered as the mechanical resultant of given situations, which may, in certain cases, be conscient, without that, however, changing anything of what they are.

Dr. Laloy begins his book by a study of parasites. He shows us in the first place the plants that live as parasites on others, such, for example, as the dodder (*Cuscuta*), which lives at the expense of the lucern, and which often causes great havoc with it. Naturally, we cannot follow the author step by step in his account so full of facts. Still, it is of interest to make known what he says about the effects of parasitism upon the parasite. The latter (and the fact is true for animal parasites) is very often characterized by changes and atrophies that give it the appearance of a type belonging to a much inferior group. Thus it is that we could not recognize a phænerogam with the anatomy of an *Orobanche*. We must mention also what relates to the means of defense employed by plants against their vegetable parasites. The most frequent are the formation of membranes capable of resisting the action of the digesting and toxic secretions of the invader or else the formation of an impermeable cortex limiting the danger.. This process may go so far as to form a close envelope inclosing the parasite. This is what is termed a gall.

Plants do not confine themselves to becoming parasites on each other. As is only too well known, they attack animal organisms, and that, too, under very diverse forms, since it is a question here of fungi and microbes. Here again the defense is very interesting. We observe, for example, in the intimacy of the circulatory system, a true hand-to-hand contest between the blood cells and the spores of the cryptogam. M. Metchnikof has admirably described such phenomena in his work on "Immunity."

Animal species in turn frequently live at the expense of plant ones. There are, for example, numerous enemies of our fruit trees, such as plant lice, coccinellidæ, etc. One of the principal means of defense is the formation of galls or cecidies. Let us mention, by the way, the close resemblance of these to fruits. This will be easily understood, however, if we reflect that the fruit itself is in reality a sort of gall that isolates from the organism the plant's disseminating apparatus, which, in awaiting maturity, live at its expense like true parasites.

Among the animal parasites of animals, we may distinguish the organic ones living directly upon the very substance of the being upon which they dwell, and parasites such as the nematodes of man that live simply by extracting their share from the food or the secretions of their host. Both, moreover, present in common those wonderful changes which are the distinguishing mark of parasites. Among them, we find numerous variants in their mode of life. Some are stationary, such as the cirriped crustaceans, which live upon other crustaceans, medusæ, sharks, or cetaceans, and certain types of which would not be taken for crustaceans if the study of their development had not shown that they plainly possess the characters thereof in their first stages. Others, on the contrary, have need of several hosts in order to traverse their evolutionary cycle in its entirety, such as the tape worms of man, which live at first in the state of cysticercus, one upon measly hogs, and the other upon the ox; or the distoma of the sheep, which passes through the liver of a mollusk of the genus *Lymnea* before becoming a parasite on the liver of the sheep. Such animals all present types of special forms adapted to each of the successive hosts. Finally, is it necessary to make mention here of a few parasites well known to our readers, and which are responsible for terrible maladies, such as the ankylostoma or miner's worm, the trypanosoma of the sleeping disease, the hematozoa of paludal and intermittent fevers?

The facts brought together by Dr. Laloy in the second part of his work under the title of "Mutualism" do not, as we have said, differ from the preceding. There are associations or groups the members of which make reciprocal concessions and lend each other mutual aid which facilitates their obtaining food. From the standpoint that occupies us and that dominates this entire article, that is to say, from the standpoint of the modifications imposed on living forms by the environment in which they chance to be placed, they are not less numerous than those which result from parasitism. The grouping of species into societies may occur between species of the vegetable kingdom, between animal and vegetable species, and between species of the animal kingdom. It is well understood that here again such distinction in great groups are necessities of exposition much more than natural categories. We shall observe in such groups various modalities of the relations of species to species, from simple agglomerations or associations determined by cosmic conditions, such as the nature of the soil, climate, etc., to symbioses realizing true organic fusion between the beings in presence, in passing through societies in which, without the existence of so great an intimacy, there are nevertheless reasons of reciprocal utility that determine the approximations and maintain them. Thus it is that we can distinguish the floras of the arctic tundras, of the temperate prairies, of the tropi-

cal savannas, of the steppes, of the deserts, of the landes, of the marshes, of the turf pits, of the littoral regions, of the forests, of the water courses, or of stagnant water and the sea, each of these floras constituting a great type of agglomeration, in the interior of which the mutual services are evidently numerous, but in which the principal cause of the approximation is the cosmic factor.

On the contrary, the grouping in vast areas of certain plants of which the pollen is transported by the wind (Graminaceæ, Coniferæ, Cupuliferæ, etc.) is a condition indispensable for the facility of their reproduction. There are comparable biological necessities that compel climbing plants to employ the support of contiguous trees in order to raise themselves to the light or which, in the interior of tropical forests, force numerous ferns and orchids to fix themselves to the summit of trees instead of obtaining their food and support in a dangerous soil. We may easily get an idea of symbiosis by imagining that a plant thus supported by another concedes to it in the way of payment, as it were, some one or another of the elements which it lacks. This is what occurs, for example, in the celebrated case of mycorhizas, an intimate association of the mycelian filaments of certain fungi with the roots of certain plants, the tree profiting by the nitrogen which is furnished to it by its host. Among the services rendered to plants by the animals which demand food from them or which seek their secretions there are some that are well known. Thus we know that the cross fertilization of many plants is possible only through the intermedium of insects and birds, and that animals disseminate likewise the seeds once formed, etc. The chapter on the relations of ants and plants will always be one of the most diverting ones of the natural sciences. It seems that in them instinct has exhausted in advance all the most subtle actions that intelligence can imagine. The harvest ants, for example, collect and store small grass seeds, etc., in their nest, and arrest their germination by eating the young plant that is in process of emerging, and afterward place them in the sun to dry, then store them up anew, and feed upon the soft and saccharine parts, and carry the seed coats outside. Other ants of the American genus *Pogonomyrmex* weed all the ground that surrounds their nest, in leveling the surface, and tolerate thereon but a single plant, a grass, which thrives all around the nest. The *Attæ* of South America devote themselves to the culture of fungi. For this purpose they prepare a material composed of comminuted fragments of leaves gathered from the trees in the vicinity, and of various other materials. It is upon this substratum that develops a fungus, always the same, the *Rozites gongylophora*. It must be stated, moreover, that the means of defense employed against ants are no less curious, or, we may say, no less ingenious, than the ones above mentioned. One of the strangest is a mode of alliance contracted by the plant with a species of ant against another species. Certain acacias are provided with hollow stipular spines, in the interior of which ants, "in garrison," find food and lodging. The cecropias of tropical America offer the *Aztecæ*, which protect their leaves against the *Attæ*, more perfect lodgings still. These are cavities that exist in the hollow interior of the trunk and which are connected with the exterior by an aperture situated above each leaf insertion. In this housing the ants rear plant lice and make their exit now and then in order to seek secretions furnished by the plant support and which they use as food.

We ought now to give a rapid sketch of what Dr. Laloy calls social life in the animal kingdom, to show the various faunas, their origin and modifications, to describe the animal societies so wonderfully organized among insects, to speak of the cities formed by birds, of the family, of the herd, and of the clan in mammals, and also of animals of different species, to penetrate anew into the tropical formicaries, to see what hosts are admitted to them as friends, parasites, or slaves, etc. But our space is unfortunately limited.

However, we think that we have said enough to show the deep and enthralling interest that has enticed Dr. Laloy's talents. Although we have, so to speak, made but a cursory examination of his book, we have seen how replete it is with singular facts and ingenious views. We have been able to persuade ourselves especially at every instant (and a more detailed study page by page would only make it more deeply felt) of the great importance of the life factor upon the form invested by the life phenomenon. It is not only between living species and raw material that there is a perpetual motion of action and reaction, which is shown by modifications and adaptations; but the same law is true for the relations of species with each other. All the forms of beings with which we are acquainted are the resultants of the conflict of living matter with these two great orders of modifying causes.—Translated from the French of Jean Lafitte, in La Nature, for the SCIENTIFIC AMERICAN SUPPLEMENT.

Alum Plaster (Marble Cement).—Calcined plaster is treated with cold saturated alum solution, then recalcined, 1-12 the weight of the plaster of alum mixed with the plaster and the casts made. They set slowly, but finally become as hard and translucent as marble. (2) Pieces of calcined gypsum as large as a fist are steeped three hours in alum water (12 parts by weight of alum to 100 parts of water) at a temperature of 35 deg. to 40 deg. C. (95 deg. to 104 deg. F.), again calcined, mixed with 1-16 the weight of powdered alum, and wetted with water containing 1-16 part of sal ammoniac to each part of plaster, to form the casting paste. Casts made from this mixture possess considerable hardness, a bright luster, and it is admirably adapted for the production of fine statuettes or delicate patterns.

A VAST NEGLECTED FIELD FOR ARCHÆOLOGICAL RESEARCH.

By HARLAN I. SMITH.

THE territory roughly included in the area known as "The Great Plains," "The Plateau Region," and "The Barren Lands," which forms such a vast portion of the North American continent, in my opinion, offers an extensive field for co-operative archæological research, since its prehistoric ethnology is practically unknown.

Its historic ethnology has recently received attention at the hands of energetic, trained anthropologists. Its prehistoric ethnology, or archæology, however, has been neglected, possibly because modern ethnological problems in that area have held the attention of visiting anthropologists, or perhaps for the reason that, on all that vast area, comparatively little literature or other material was available. Few archæological sites are known, and literature on the whole subject is scant, even clews to sites being of rare occurrence in papers on other subjects. Archæological specimens from the region in question, both in museums and in private hands, are not numerous; and those that do exist show a narrow range of forms, and, with few exceptions, have little or no individuality. All these facts have no doubt contributed to the causes of this deplorable neglect. A further reason was probably the supposition that the region was uninhabited until comparatively recent times; that it was an area where only a few finds could be expected as a reward for the persevering toil of the investigator; and that such finds would be of only a few types, of crude technique, and of a low order of art.

Some archæological work, however, has been done in this area, notably in Wyoming, but by anthropologists chiefly interested in problems relating to the ethnology of the present peoples.

The scarcity of archæological specimens from this vast area, and the dearth of literature on the whole subject, may be due to the fact that until recently no one fitted to collect or to write has visited the region, it having been occupied by white people only lately, and not even visited by them until comparatively recent times. It must also be remembered that the lumbermen, cattlemen, miners, and railroad men, who have made up a large percentage of the white people who have been in the territory, belong to a shifting population, not given to the examination, much less to the preservation, of archæological objects; while until very recently the number of farmers and settlers has been small. These stable people, having homes, possess means of caring for such specimens as appear to them interesting. Had they been in the region for a longer time, or even in greater numbers, we might have had more data upon which to work.

On the other hand, the scarcity of archæological material may be due to the comparatively recent occupation of the area by Indians, or to a sparse population, if not to both of these causes. It is quite possible that the plains were not thickly populated before the introduction of the horse, the acquisition of which, no doubt, gave a great impetus to migration throughout the entire plains area.

The area, more particularly but roughly defined, includes the western half of the Dakotas, all of Nebraska, the western third of Kansas, Oklahoma, a wide strip north and south through Texas, all of Colorado except a small portion in the southern part of the State, Utah with the exception of a small area in the southeastern part, Nevada, Wyoming, Idaho, Montana, and the vast adjacent portion of the British possessions. It includes, among great natural divisions, the upper valley of the Missouri, that of the Platte, the Upper Arkansas, the Great Basin, the Upper Columbia Valley, the Yukon Valley except near the mouth, the Mackenzie Basin, and the area draining into Hudson Bay. Linguistically the area embraces all of the territory inhabited by the peoples of the Kiowan and Kitunahan stocks, and the greater part of the areas inhabited by those of the Siouan, Shoshonean, Caddoan, Athapascan, and Algonquian stocks. The Siouan, Shoshonean, and Athapascan areas correspond to that part of the region regarding which we are in perhaps the greatest need of archæological data.

This whole area separates, or is in part bounded by, the Pueblo and cliff-dwelling culture-area, that of the Mississippi Valley, that of California, and those of the North Pacific coast and the plateaus of Washington and southern British Columbia as now outlined. An exploration of it would probably exactly define the limits of these culture-areas and the presence or absence of an intermediate culture area or areas.

It must be remembered that pottery of certain well-known kinds is one of the great characteristics or marks of individuality of the Pueblo area and of the prehistoric culture of the Mississippi Valley and forest area to the northeast, while, on the other hand, no ancient pottery is known from the California area or the Northwest coast. Both of these latter regions are so well known, that the absence of pottery, or at least its great scarcity, is determined; but its presence in the wide northern area of the interior of British America is possible. It is true that pottery has been found in Alaska which closely resembles that from the adjacent portion of Siberia. The art of making it may have come from Siberia; so that it does not necessarily lead us to expect to find pottery in the Upper Yukon, the Mackenzie Basin, or, in general, in the Canadian Northwest.

In 1904 I called the attention of the Anthropological Club of Harvard University to the need of archæological investigation in the area lying between the plateau region of southern British Columbia and the cliff-dwelling and Pueblo region of the Southwest, pointing out at the same time the absence of pottery in the former area, its great development in the latter, and the interest which we have in defining the line separating the region where pottery was made from that where it was not made.

The need of archæological work in this vast territory is felt by students of historic ethnology. As has already been mentioned, they have started well in working up the area, and they would certainly be interested in the prehistoric relations of their problems. The length of time the various parts of the area have been inhabited, the history of every culture that has developed there, the modification of such cultures as may have been brought into the territory, their causes, and the migrations into and round about over the area —all these may be mentioned among the problems to be solved.

It is true that in this region we may hardly expect to find archæological material comparable to that found in the Southwest, Mexico, and Peru, especially the kind that would appeal to architects, artists, travelers, and students of modern history. But, however entertaining it might be to contribute to these interests, it must be borne in mind that archæological work is not done solely to meet the needs of those interested in these subjects; it is the professional duty of the archæologist to reconstruct prehistoric ethnology even in fields that are held to be barren or largely so, and negative results are helpful in arriving at a knowledge of the prehistoric ethnology of the whole of our continent.

Judging from what we know, however, we may expect to solve a number of problems by working over this area. It would seem advisable to conduct this archæological work in co-operation with students who are investigating living tribes; for a study of the modern Indian of a certain spot throws light on the archæology of the region, and an understanding of the antiquities of a given place is helpful in the study of its natives. Furthermore, by this system, the continuity of historical problems is met by a continuity of method.

In selecting successive fields of operation, it would seem best to continue explorations in an adjacent area, sufficiently distant from those already examined to present new conditions and give promise that new facts may be discovered, possibly a new culture-area. At the same time a new field of operations should be so near, that no unknown culture-area may intervene. Thus the limits of culture-areas may be determined and new areas be discovered. This method of continuing from past fields of exploration makes valuable the experience gained there in each successive field, while the discoveries in every region may always lead to a better understanding of the areas previously explored. If the results obtained in an area are not yet printed, the light thrown upon them by latter work is at once available for the original publication.

In accord with this plan, it would seem best that those explorers who are familiar with the Pueblo and cliff-dwelling region should examine the adjacent part of this vast area, especially in Kansas, where remains of pueblos are known to exist, and in the basins which drain into the Colorado and the Rio Grande. To define the limits of Pueblo culture would certainly be of interest to them, while at the same time their exploration in the adjacent country would add to the data needed by their co-workers.

In like manner the anthropologists of California are no doubt nearly as familiar with the prehistoric ethnology of Nevada as are those interested in the Pueblo region. Probably they will be more interested in it; and from their active investigation of the cultures of the prehistoric inhabitants of their State, who depended so much upon that natural product the acorn, we are led to look to them for the examination of the region between California and the great Cañon of Colorado. It would seem best that those who have explored in the Lower Columbia Valley and the plateau region of Washington and southern British Columbia should push their investigations eastward throughout the area drained by the Columbia and the Snake, thus attempting to define the eastern limits of the Plateau culture, to bound it, and to further our knowledge of it. Again, the explorers of the Mississippi Valley are perhaps best fitted to investigate the western limits of the culture found there. Some of these individuals are already interested in the prehistoric migrations of the Mandan, who are thought to have taken a northwesterly course from the Mississippi to the Missouri. The Historical Society of North Dakota has begun an investigation of the antiquities of its own State. Therefore archæological investigations in North Dakota may probably be largely left to that society. The Historical Society of Nebraska has expressed a desire to advance archæological research in its State, and possibly it may be able to explore even more than that part of the field.

From another standpoint, the ethnologists interested in the historic Indians might take up prehistoric ethnological work—students of the Siouan groups in the Siouan area, those of the Shoshonean group in the Shoshonean area, and students of the Athapascan group in the Athapascan area. By following this line of investigation, the work of just these men would clarify the problems of the whole situation.—Reprinted from Boas Anniversary Volume, 1906.

SCIENCE NOTES.

The Madagascar plant known as *Raphia Ruffia* contains a variety of wax which has been examined lately at Paris by M. A. Haller. Such wax can be obtained in considerable quantities in the country, where it is a secondary product in the preparation of Raphia fibers, and these give about ten per cent of it. The wax differs from beeswax and has the characteristics which will be mentioned. In an account presented to the Académie des Sciences, the author states that the wax is of a light brown hue and is almost insoluble in most of the organic solvents in the cold, but dissolves more easily when heated, as concerns alcohol, benzine, chloroform, etc. Boiling benzine is the best solvent found for it. When the wax is exhausted by hot alcohol we obtain a light pinkish liquid which upon cooling forms a gelatinous and white mass. This dried product is white and brittle, but when melted it takes the dark red color again and has the same melting point, 80 deg. C., as the crude wax. It cannot be bleached by charcoal. Alcohol does not dissolve all the wax, but leaves about ten per cent of a brown residue, melting near 77 deg. and soluble in boiling benzine. When distilled *in vacuo* the crude wax furnishes a light pinkish product which comes over from 280 to 300 deg. C., and there remains in the crucible a blackish mass having an empyreumatic odor. The distilled part has the same melting point as the portion which is soluble in alcohol, and only differs by its color. Analysis of the crude wax, as well as of the wax distilled or extracted by alcohol, gives the formula $C_{25}H_{52}O$. Different kinds of wax have been discovered by M. Etard in the leaves of various plants, especially in oats, barley, and wheat, and he assigns them the same formula as above. The author compares his product with such wax known as *luzernol*, furnished by M. Etard, but the two products have not the same melting points. While the *Raphia* wax melts clearly at 80 deg. C., the *luzernol* has the melting point at 76 deg.

A somewhat striking property of platinum amalgam, which was observed by the late Henri Moissan, was presented recently to the Academie des Sciences. When mercury is shaken up with water, the two liquids separate, as is well known, as soon as the agitation ceases. It is not the same when mercury is used which contains platinum in solution. After fifteen seconds agitation or even less, the platinum amalgam forms a semi-solid mass of the consistency of butter, having about five times the volume of the original mass. The emulsion thus formed resists the action of time, and does not appear to have changed in volume at the end of a year. It also resists the action of heat, and it can be heated to the boiling point of water without destroying it. This rise of temperature does not seem to change its volume nor cause it to give off gas. It also resists the action of cold, and platinum amalgam, formed into emulsion with water colored with fuchsine, was cooled to —80 deg. C. The emulsion subsists at this temperature, and it could be cut in sections and examined rapidly under the microscope. Water drops are found to be disseminated in the amalgam and give it a cellular aspect. *In vacuo* the emulsion diminishes in volume, a small amount of water is separated, and some gas bubbles are given off. Amalgams of copper, silver or gold do not produce the emulsion. These amalgams act like pure mercury and separate from the water. As to the platinum amalgam it gives the emulsion not only with water, but also with many other liquids such as sulphuric acid, glycerine, alcohol, ether, and chloroform. All the emulsions are stable after one year at least. If we shake up one part of pure mercury with six parts distilled water containing a few drops of a ten per cent platinum chloride solution, the emulsion is produced. Using platinum amalgam as above, but adding a little platinum chloride to the water, the effect is more strongly marked than with pure water.

In a paper presented to the Académie des Sciences, M. A. Bouchonnet describes a series of new compounds which he succeeded in obtaining. The alkaline arsenites, especially those of potassium, are often ill-defined, but it is not the same for the arseniates, and these are generally obtained in a well-crystallized form. No researches seem to have been made for obtaining the oxygenated compounds of arsenic with rubidium and cæsium. The author, however, now prepares the meta-arsenite of rubidium and also the ortho-arseniate and other similar compounds. As concerns the meta-arsenite, he obtains it by dissolving in water equal molecular weights of vitreous arsenious anhydride in powder and carbonate of rubidium. After heating on the water-bath for one hour the evaporation is carried out *in vacuo* in the presence of caustic potash. The reaction is as follows: $As_2O_3 + CO_3Rb_2 = 2AsO_2Rb + CO_2 + H_2O$. At the end of a few days there remains a sirupy mass which is finally dried by placing on a porous plate *in vacuo*. Thus he obtains a white amorphous and anhydrous powder, soluble in water and insoluble in alcohol. Heating the aqueous solution, the product is transformed into arseniate which is recognized by the brick-red precipitate it gives with nitrate of silver. Its reaction is alkaline, and it has the general characteristics of the arsenites, reducing permanganate of potash. Another body, the monobasic arseniate, is prepared in the following way: Equal parts of arsenious anhydride and nitrate of rubidium are melted together, then taken up with water, filtered, and evaporated *in vacuo*. Or again, we neutralize an aqueous solution of rubidium carbonate by arsenic acid, then crystallize as above. In the first case we obtain flat crystals and in the second needle crystals having a silky aspect and grouping in star-like tufts. The product is always anhydrous and it is quite soluble in water without, however, being hygrometric. When heated, the monobasic arseniate melts at low redness, losing its water of crystallization, and is transformed into meta-arseniate, as O_2Rb, which is a crystalline mass of a milk-white color, less soluble in water than the preceding. At a bright red heat it is decomposed with formation of arsenious anhydride, which volatilizes. The third compound, the bibasic arseniate of rubidium, is prepared by mixing the aqueous solutions of rubidium hydrate and monobasic arseniate, in quantities calculated from the formula $AsO_3RbH_2 + RbOH = AsO_4Rb_2H + H_2O$. Upon evaporating, we have a very hygrometric product which is crystallized in flat white crystals. When heated, the water is driven off and above 150 degrees C. the product is transformed into pyro-arseniate, $As_2O_7Rb_4$. The bibasic arseniate is quite soluble in water and insoluble in alcohol, and rapidly absorbs carbonic acid from the air, especially when in solution. Another new compound, the tribasic arseniate, AsO_4Rb_3 is also formed by the author.

ELECTRICAL NOTES.

A German inventor, August Kufferath, has obtained patents in leading countries for a special method of treating arc lamp carbons which gives the light from the lamps a special quality and this is claimed to be much superior for photographic and other similar work. The inventor obtains these properties by treating the carbons with a solution containing from ½ to 1 per cent of a mixture of equal parts of nitrate of yttrium and nitrate of lead. Carbons which are prepared in this way cannot be distinguished from ordinary carbons as regards the yield of light and the amount of current which is used, but the light is found to have a considerably higher actinic power. The treated carbons will burn without forming slag, and the light is especially rich in violet rays. It is found that the actinic power does not depend upon the luminous value of the carbons, but rather upon the way in which they have been prepared.

The city of Lyons, which is one of the best equipped in France as regards the use of current from distant hydraulic plants, has lately received the demand for a concession for a new power line from one of the leading companies, the Grenoble Light and Power Company. This firm already possesses several hydro-electric plants in the Isère and Savoie departments, and runs an extensive series of power transmission lines which are operated on the three-phase system. One of the leading substations of the company is located at Vaulx and this plant receives current from the main line at high tension and transforms it to low tension current for local use. The total power of the dynamos and motors which are erected in the station is estimated at 6,000 kilowatts. Of this amount of power, the company propose to furnish 1,000 kilowatts to be used at Lyons and the line would end in the city at the Villeurbanne plant, which belongs to the City Gas Company. The Municipal Council is now considering the feasibility of the above project.

The subject of Principal S. P. Thompson's second lecture, delivered at the Royal Institution on Saturday, April 20, was the compass. Rare old prints, quaint and modern compass cards, and models, covered the lecture table, and the discourse was chiefly of historical interest. In his first lecture Dr. Thompson had referred to the first part of the remarkable letter of Petrus Peregrinus, of 1269. The second, most wonderful, part of this letter, the lecturer said in his second discourse, contained the descriptions of three instruments: a floating lodestone, surrounded by a divided circle of the astrolabe pattern; a true compass, with needle to be touched by the lodestone, transverse needle axis of brass, top and bottom pivots, transparent divided circle, and a kind of roof; a *perpetuum mobile*, whose chief part was a pivoted magnet. There had certainly been crude compasses before this invention of the pivoted magnet by Peregrinus. A cardinal accompanying the fourth crusade, 1204 (which ended with the conquest of Constantinople and the establishment of the Latin Empire there, 1204-1261), commented on the use of compasses floated with the aid of two pieces of cork instead of one piece. The crusades favored the rapid spreading of the compass to the northern countries. Flavio Gioja, of Amalfi, who had so often been credited with having invented the compass in 1304, was a mythical person; but it was probable that the sailors of Amalfi—an important port in those days—improved the compass and put it into a box; one of Dr. Thompson's beautiful prints, showing a compass-box with sight, bore the inscription "pixis vel buxola," from which words the Italian and French terms for the compass seemed to be derived. As regards the Chinese priority, Klaproth had proved, in his correspondence with Humboldt, that in Chinese manuscripts there was not any reference to lodestones prior to the second century B.C.; magnetic needles were first mentioned in 121 A.D., floating needles in 1111, pivoted needles in 1297; yet the Chinese still used floating needles in 1680. Dr. Thompson proceeded to demonstrate by a large number of illustrations from old manuscripts and prints the evolution of the compass-card from the wind-roses of the ancient Greeks and other nations. As regards the magnets, Peter Barlow introduced, about a century ago, the four (or five) small parallel needles of the Admiralty pattern compass, which Lord Kelvin later improved, principally by reducing the weight. Kelvin's card consisted of an aluminium rim, silk cords, and six fine needle-magnets. Gowan Knight had used several parallel magnets about 1775. The favorite shapes of the magnets had been diamonds, in full or only in outlines, and bars, with straight or indented ends, pivoted flat or edgeways. With the aid of iron filings, Knight had proved that a lens-shaped magnet, consisting of two flat arcs joined by a bridge-piece, readily took up a strong magnetism, but that this shape also developed false poles easily.

ENGINEERING NOTES.

Steam turbines are to be applied to war vessels for the first time in France, and they have been officially adopted for six battleships of the new naval programme. Following the report of the commission which was sent some time ago to England, the Minister of the Marine decided in the first place to use Parsons turbines upon the torpedo destroyer "Chasseur" in construction at the Normand Brothers docks at Havre. They had already built the torpedo boat No. 293 with turbines of the same system. For the "Chasseur" the turbines are now in construction at the establishment of the Compagnie Electro-mécanique in the suburbs of Paris, which has exclusive rights for the Parsons wheels for France. Quite recently, and after long debates in the Senate and Chamber of Deputies, the Minister of the Marine furnished the constructors with the data in regard to the turbines for the battleships. The latter had been divided among the state arsenals and the leading private docks, among which are the Mediterranean docks and the St. Nazaire-Penhoet docks, and as these two establishments are the only ones which have a license from the Compagnie Electro-mécanique, they are to build not only their own turbines, but those which are needed for the other vessels. The new battleships will have a displacement of 18,350 (long) tons and the standard speed is to be 19 knots. As to the turbines, they are to give about 22,500 horse-power. There will be eight turbines for each battleship, and they will operate four helice shafts. The helices will measure 2.800 meters (9 feet 4 inches) in diameter, and will run at 300 revolutions per minute. It will be remembered that England now has as many as fifty vessels complete or building and using steam turbines, representing 600,000 horse-power. France will now come next, with 144,150 horse-power, and Germany third, with 57,600 horse-power. The latter figure does not include the projected vessels.

Of considerable interest are the researches made by Em. Vigoroux, of Paris, upon the alloys of nickel and tin. He desired to form a kind of bronze in which the copper is replaced by nickel. The present experiments bear upon alloys which contain more than 66.7 per cent of tin. The first alloy is formed by using a much greater weight of tin than of nickel. In a small magnesia tray is spread nickel powder and upon it is laid a small bar of tin. The whole is placed within a porcelain tube traversed by a current of pure hydrogen, and the tube is heated in a small furnace which can soften the porcelain. After the heat, which does not exceed 45 minutes, the apparatus is left to cool slowly. In this case the product appears as a melted mass, seemingly homogeneous, having 73.64 per cent of tin and the rest nickel. Of an iron-gray appearance and crystalline texture, the ingot is hard, as it is difficult to scratch it with a steel point; and also brittle, as it breaks when let fall on a stone. It is sonorous and non-magnetic. Acids either dissolve it or disintegrate it. With nitric acid the latter is the case and a white powder of meta-stannic acid is formed, while small brilliant and crystalline fragments are detached from the mass. In the second experiment the amount of tin is increased, using the same method as before. The ingot now contains 83.65 per cent of tin, and it is hard and brittle, having a grayish section approaching a blue color. At the surface are blow-holes filled with a lining of small crystals which are clearly seen. This alloy is not nearly as sonorous as the preceding. Nitric acid attacks it, forming meta-stannic acid and a metallic residue. A still greater proportion of tin is used in the third alloy, this being 92.71 per cent. The metal has a bluish white color, and nearly resembles tin in appearance. It is easy to cut and flatten and is not sonorous, but it is somewhat harder than pure tin. Hydrochloric acid dissolves it entirely, and nitric acid has about the same action as above. The conclusion from the above experiment is that by the direct action of pure nickel and tin we obtain alloys whose respective values of tin are 73.64, 83.65 and 92.71 per cent, the rest being entirely formed of nickel. The first of these alloys has the particularity of being sonorous, like certain ordinary bronzes. All the alloys are non-magnetic, which leads to the conclusion that the nickel is not in a free state, and they give a metallic residue when treated with nitric acid. Following the first series of experiments, M. Vigoroux treats the alloys with nitric acid and potash, and succeeds in isolating a definite compound of nickel and tin, Ni Sn, having 33.24 per cent of nickel and 66.76 per cent tin. The first ingot mentioned above is roughly broken and treated by hot 25 per cent nitric acid solution. But little of the nickel is dissolved, and most of the meta-stannic acid is eliminated by decanting and the metallic residue is further cleared by melted potash. All the free tin is thus taken off, and the residue is found to contain 33.45 per cent nickel and 66.88 tin, total 100.33. The other ingots give like results, and the residue which is obtained corresponds very closely to the value for Ni Sn. This substance appears generally as a silver white crystalline body which shows brilliant faces under the microscope. It is non-magnetic, unlike pure nickel. The density is near 8.44, while the calculated density is 7.93, and the formation of this body must be accompanied by a certain contraction.

TRADE NOTES AND FORMULÆ

Aniline Bronze Color for Textiles.—10 parts by weight of fuchsine and 5 parts of aniline purple (methyl violet) are dissolved in 100 parts of absolute alcohol, with application of heat. Five parts of benzoic acid are then added and the mixture boiled for 5 to 10 minutes.

Etching Fluid for Copper, Brass, and Bronze (according to Puscher).—The plates, properly covered with the ground, are etched with concentrated nitric acid, 3 parts by weight, water 1 part, to which one-half part of pulverized bi-chromate of potash has been added and stirred until dissolved. From time to time a little chromate of potash must be added to the fluid.

To Transform Agate into Onyx.—Polished, banded stones are exposed for eight days to the action of a solution of iron in nitric acid. Thereupon the portion of the stone which it is desired shall be white, or yellowish white, is impregnated in like manner and for a similar period, with a mordant made of caustic potash dissolved in water. The stones are then dried for eight days on a stove, and finally calcined in a closed earthen pot.

Decalcomania (metachromotypes).—These are the well-known pictures printed in color on paper that can be transferred from the paper to any other surface by pressing the picture side, previously moistened, on to the surface to which the picture is to be transferred, then pressing the paper firmly against the other surface, so that the picture will adhere to it. Before printing on the lithographic press, which should be done in reverse order of the colors, the paper should be repeatedly coated with paste, tragacanth, and mucilage, so that the colors are impressed on this ground, which is so softened by the wetting that it separates from the colors. Such pictures have proved very useful as a substitute for painting in china decorating, and in such cases must, of course, be printed in china-painting colors, for printing advertisements on tin (metal printing), for wood graining, and imitations of marble in painting.

Non-Arsenical Preparation for Anointing Skins of Animal Bodies Previous to Stuffing.—125 parts by weight of colocynth and 25 parts of aloes with 1,500 parts of water, concentrated by boiling to one half and strained while hot. Prepare separately 500 parts brown rosin soap and 250 parts of soft soap, melted over a gentle fire and stirred with a little water to a paste. Mix with the first decoction and 125 parts of glycerine and 40 parts of rapeseed oil carefully over the fire. Into the mixture thus produced thoroughly incorporate 50 parts of naphthaline crystals (finely pulverized), 35 parts of oil of turpentine, and 8 parts of carbolic acid.

Etching Fluids for Metals.—a. For copper: 150 parts of fuming muriatic acid, diluted with 1,050 parts of water, to which a boiling solution of 30 parts of chlorate of potash in 300 parts of water are added. For weaker effects the etching fluid may be further diluted with 1,050 to 2,050 parts of water. b. For zinc: 600 parts of water and 45 finely-crushed gall nuts are concentrated by boiling to one-third and filtered through a felt or linen filter, and add 3 drops of concentrated nitric acid and 4 to 5 drops of muriatic (hydrochloric) acid. Dilute for fine work. After etching, cover the zinc with a dilute solution of gum arabic. c. For steel: 45 parts of glacial vinegar, 11.5 parts of absolute alcohol, and 11.5 parts of concentrated nitric acid. The glacial vinegar is first mixed with the alcohol, and they are permitted to work on each other for 30 seconds; after this time the nitric acid is added. 2. Mix carefully 15 parts of red fuming nitric acid and 75 parts of acetic acid, diluted with distilled water if desired. 3. For steel engraving work, 125 parts of 80 per cent spirits of wine, 9.5 parts of concentrated sulphuric acid, and 1.5 parts of lunar caustic. The ground, which must either be painted on with oil of turpentine, or if the work is to be etched with a point, melted on, must consist of a mixture of 6 parts of asphalt and 1 part mastic melted together.

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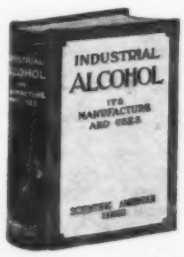

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